Long Range Biosolids Management Plan

THE METROPOLITAN GOVERNMENT OF
NASHVILLE AND DAVIDSON COUNTY

Metro Water Services

Black & Veatch Corporation
B&V Project 69979

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EXECUTIVE SUMMARY

Until 1994, Nashville Metro Water Services used incineration as its primary method of disposal for wastewater solids. Incineration involves burning the wastewater solids using natural gas, which greatly reduces volume by producing an ash that is landfilled. Raw sludge with high volatile solids content is preferred for incineration to reduce the amount of natural gas that must be purchased. As a result, no treatment of the sludge was provided, reducing operating costs for incineration. In 1993, 40 CFR Part 503 regulations imposed more stringent air emissions limits on sewage sludge incinerators. To meet these emission standards and continue operation would have required major modifications and significant capital investment to the Central Wastewater Treatment Plant incinerators. Consequently, incineration was abandoned at Central. In the intervening years, Nashville Metro Water Services has made several attempts to dispose of wastewater residuals through beneficial use. These efforts included on-site composting at Central and off-site contracted composting by a private contractor. Both efforts were unsuccessful. As a result, Metro Water Services currently disposes of its raw solids through landfilling. This practice limits flexibility in that it provides only one outlet for disposal of Metro's solids and involves hauling a large volume of material through the area surrounding two of the treatment plant sites.

Another issue concerning the wastewater residuals management program relates to the existing facilities and equipment. In the last 10 years, there has been little investment in Nashville Metro Water Services residuals management infrastructure at its three wastewater treatment plants – Central, Whites Creek, and Dry Creek. The Whites Creek plant currently pumps sludge to the Central plant for dewatering and disposal, and will continue to do so in the future. Upgrades to residuals treatment at Central and Dry Creek have lagged behind those provided for liquid stream improvements.

Metro Water Services decided to evaluate its current wastewater solids management system and determine the most effective management and treatment processes for the future. A project team, consisting of Metro Water Services personnel, Metro Government staff, Black & Veatch, and Katcher, Vaughn & Bailey conducted a screening process to identify viable treatment and management alternatives.

As a first step in this process, the existing facilities were evaluated to determine their suitability in supporting future residuals production. Inspections at the three plants and discussions with Metro Water Services staff resulted in the following improvement issues:

- Improve or replace existing facilities for handling solids at Central. The current facilities include a "temporary" thickening building and dewatering equipment housed in the retrofit incinerator building. Existing facilities and equipment layout are not conducive to effective operation. The vast majority of existing equipment is at the end of its useful life.

- Water Services currently produces raw sludge, which must be sent to a landfill or incinerated. In order for any alternative outlet for residuals to be considered, additional treatment facilities must be constructed to produce **biosolids**, which is sludge that has been treated to meet EPA standards for reuse.

- Address on-site and off-site odors at Central and Dry Creek. Odors are currently generated during treatment, handling, and transportation of raw solids.

- Improve or augment sludge storage at Central and Dry Creek. Current storage facilities have inadequate volume for weekend storage.

- Address scum/grease volume at Central and Dry Creek. Current liquid stream processes result in large amounts of scum that interfere with operation of the solids handling facilities.

The initial screening process focused on the final use program, since it controls processing and handling requirements. The 40CFR Part 503 regulations established two levels of biosolids quality with respect to metals and pathogen densities. Class A biosolids meet stringent pollutant and pathogen reduction limits and are considered to be a product that has very few restrictions for use, whether used in bulk, sold or given away in bags or other containers. Class B biosolids must meet less stringent pollutant limits with a lower level of treatment for pathogen reduction. However, Class B biosolids must meet the management practices, site restrictions, monitoring and reporting requirements included in Part 503 for land application. During a workshop with team members, the following possible final use/treatment options were discussed:

- Disposal.
    - Landfill disposal (raw or digested biosolids)
    - Incineration of raw biosolids

- Bulk land application of Class B solids
    - Anaerobic Digestion
    - Alkaline Stabilization
- Distribution and marketing of Class A solids.
    - Heat drying (raw or digested biosolids)
    - Alkaline stabilization (raw or digested biosolids)
    - Composting (raw or digested biosolids)
- Conversion to/use as a fuel
- Conversion to/use in building materials

During the screening process, bulk land application of Class B solids was eliminated due to problems that Metro Water Services had previously experienced with land application, the amount of land required for an effective land application program, and concerns with the viability of long term Class B land application. Although Class B land application was eliminated, anaerobic digestion remained as an alternative since it is almost always used as the first step in sludge treatment at large utilities. Anaerobic digestion stabilizes sludge through biological degradation and produces methane gas, which may be used as a fuel or source of heat. Conversion to fuel products or building materials was also eliminated from further consideration based on the lack of full-scale operational history for these systems.

After a second workshop with the project team, the list of options was reduced to three. The remaining options were subjected to a detailed evaluation including economic and non-economic criteria. The options were as follows (the body of the report identifies these alternatives by their respective number in the original list of options).

Alternative 1 - Landfill raw, dewatered solids from Central and Dry Creek

Alternative 2 - Landfill anaerobically digested, dewatered solids from Central and Dry Creek

Alternative 3 - Heat dry digested, dewatered solids from Central; landfill digested, dewatered solids from Dry Creek

The results of an economic evaluation of the three alternatives are presented in Table ES-1. To evaluate alternatives with different capital and operating costs, a Net Present Value (NPV) was calculated to give an equivalent comparison for each alternative. The NPV represents the sum of capital costs plus the present value of long-term operation and maintenance costs. The present value of operation and maintenance costs represents the amount of money in today's dollars that would need to be placed into a savings account to cover the costs of operating and maintaining the facility for the next 20 years. The NPV reflects the value of each alternative for the life of the project.

A comparison of costs shows that Alternative 1 – Landfilling raw dewatered solids – has the lowest initial project cost, but the highest annual operating and maintenance (O&M) cost. The capital cost for landfilling raw sludge is considerable, since it involves construction of a new building at Central to replace the existing thickening and dewatering facilities. This alternative also has a high O&M cost, which stems from the fact that the solids must be transported to a landfill for disposal.

Alternative 2 – Landfill anaerobically digested sludge at Central and Dry Creek – adds nearly $30 million in capital cost for the digestion facilities, but results in a slight decrease in O&M cost due to the volume reduction that occurs through digestion. The incremental increase in NPV for the digestion alternative is about 11% over the NPV for landfilling raw sludge, and the additional investment results in improvements in odor control and some reduction in truck traffic.

Alternative 3 – Heat dry digested sludge at Central and landfill digested sludge at Dry Creek – represents an attractive combination of treatment technologies at the Central plant. Heat drying coupled with anaerobic digestion is effective because the methane gas produced through digestion can provide most of the energy required to evaporate the moisture from the biosolids. The final product is a pellet that offers value as a fertilizer and does not have to be landfilled. In addition, the heat drying facility at Central would be an efficient operation due to the large volume of solids treated and the fact that Central currently dewaters sludge 24 hours per day. Heat dryers need to be operated nearly continuously in order to be efficient, and this fits into the operational schedule at Central. Heat drying at Central adds nearly $30 million on top of the capital cost for Alternative 2, but lowers O&M costs considerably since the treated product does not have to be landfilled. Consequently, the NPV for Alternative 3 is only 5% higher than Alternative 2, but results in nearly 85% of the solids produced by Water Services being diverted from landfills and reused in an environmentally sound manner.

The study also examined the possibility of heat drying at the Dry Creek plant site. Heat drying at Dry Creek would add approximately $13 million to the capital cost for the plant upgrade, but would result in a slight increase in O&M cost. While the cost for landfilling would be eliminated as in the example of heat drying at Central, the decrease would not be enough to offset the increase in labor cost required to operate the dewatering and drying facility. Dry Creek currently operates the dewatering facility six to eight hours per day, which would need to switch to 24-hour operation for heat drying. Thus, labor expenses would increase, and the facility would not benefit from the economy of scale reflected at the Central plant.

A sensitivity analysis was also performed to determine the effects of varying operating costs on the NPV of the alternatives, focusing on three cost parameters: landfill transport and tip fees, natural gas prices, and potential product revenue. The results of this analysis showed that minor changes in these parameters would not shift the conclusions of the economic analysis. Product revenue generated from the sale of heat-dried pellets has been used by some utilities to offset transport and handling costs. For this study, the pellets were assumed to have zero value. Sale of the pellets was assumed to generate no revenue, and no cost was associated with disposal.

From a non-economic perspective, landfilling raw solids has the simplest operation, but has the most risk associated with odor potential of the end product, heavy truck traffic from the plants, and lack of flexibility for disposal. The heat drying alternative is more mechanically complex, but provides a major reduction in truck traffic and the odor characteristics of the treated product are better. Heat dried product that cannot be distributed to customers can be landfilled, providing a backup disposal method. The alternative for landfilling digested solids falls in the middle – product odors and truck traffic are reduced, but the alternative has only a single outlet for the digested cake.

Based on the economic and non-economic evaluations, the project team has selected Alternative 3 – heat drying digested solids at Central and landfilling digested solids at Dry Creek – as the preferred long-term plan. Costs for this alternative are comparable to the costs for landfilling digested solids from all the plants, yet the non-economic benefits of adding drying are significant. Odors associated with transportation of the treated product should be minimized at Central and Dry Creek and truck traffic at Central will be decreased by almost 70%, making this alternative more neighborhood friendly. This alternative also allows for the possibility of teaming with the private sector in the future for additional treatment of the biosolids at Dry Creek. Selection of this alternative also allows recycling of the majority of Metro's solids while providing Metro Water Services flexible solids management options.

Several delivery options are available for implementation of the recommended management plan. Conventional delivery, which is the most traditional delivery method, includes separate steps for obtaining engineering and construction and usually results in longer construction lead times than design/build or design/construction manage delivery. Design/construction management delivery allows design to proceed traditionally with construction/procurement packages developed, bid, and awarded while design proceeds. Design/build delivery combines some of the engineering and construction selection, bidding and award, and preliminary and detailed design steps, potentially reducing the construction lead time. Since the lead time associated with design/build delivery is specific to each job, time savings can vary. Design/build delivery can also include facility operation and/or maintenance by the contracting firm.

The recommended delivery method for implementation of the improvements to the biosolids facilities at the Central WWTP is design/build, which is appropriate to expedite project completion, particularly when the project involves construction of new facilities on a new site rather than renovation of existing facilities. The recommended delivery method for implementation of the biosolids facilities at the Dry Creek WWTP is design/bid/build since the project will involve a significant amount of retrofitting and some new construction on the existing plant site.

Table ES-1. Summary of Alternative Costs			
	Project Cost ($ millions)	**Annual O&M (2001) ($ millions/yr)**	**Present Value ($ millions)**
Alternative 1– Landfill Raw, Dewatered Solids from Central and Dry Creek			
Central/Whites Creek	$ 42.9	$ 4.9	$ 122.0
Dry Creek	$ 3.6	$ 1.0	$ 19.6
Total	***$ 46.5***	***$ 5.9***	***$ 141.6***
Alternative 2 – Landfill Digested, Dewatered Solids from Central and Dry Creek			
Central/Whites Creek	$ 65.6	$ 4.2	$ 133.8
Dry Creek	$ 11.0	$ 1.0	$ 27.4
Total	***$ 76.6***	***$ 5.2***	***$ 161.2***
Alternative 3 – Heat Dry Digested, Dewatered Solids from Central, Landfill Digested, Dewatered Solids from Dry Creek			
Central/Whites Creek	$ 95.4	$ 3.0	$ 141.9
Dry Creek	$ 11.0	$ 1.0	$ 27.4
Total	***$ 106.4***	***$ 4.0***	***$ 169.3***

I. INTRODUCTION

A. Background and Purpose

Metro Water Services of Nashville, TN, provides wastewater treatment for the metropolitan Nashville area using three activated sludge treatment plants. Solids generated at these plants are currently dewatered and then hauled to landfills for disposal. The solids handling facilities at both Central and Dry Creek have been identified as large sources of off-site odor complaints. The current management practice depends on landfill availability. The operating cost of the solids management is largely dependent on transport costs and tip fees. These costs are rebid or renegotiated every three to five years. Little investment in the solids handling facilities has been made over the last ten years. Therefore, the majority of the existing equipment is at the end of its useful life and is very maintenance intensive. For these reasons, Metro Water Services identified the need to evaluate the long-term viability of the current solids treatment and disposal practices and to develop a long range biosolids management plan. This report summarizes the results of the evaluation of residuals management alternatives, including the process used to identify and select alternatives. It also provides the preliminary design criteria for the recommended alternatives and preliminary project construction and operating costs.

B. Scope

The first step of the planning study was to evaluate existing facilities and operations related to residuals handling. Future solids quantity projections were then developed based on current production and anticipated growth in the area supported by Metro Water Services.

Next, potential residuals management alternatives best suited to the opportunities and constraints associated with Metro Water Services' treatment goals were identified and screened by the project team at a series of workshops. The project team consisted of Metro Government and Metro Water Services staff, Black & Veatch, and Katcher, Vaughn, & Bailey personnel. The selected alternatives were then evaluated using both economic and non-economic factors.

II. EXISTING FACILITIES

Metro Water Services has three major wastewater treatment plants, 97 sewage pumping stations and 2,700 miles of collection lines. MWS is in the eleventh year of the Overflow Abatement Program (OAP), a major capital improvement program to reduce overflows from both the combined sewer system and separate sanitary sewer system. As a result of the OAP, the three treatment plants and all major pumping stations have been upgraded along with extensive sewer system rehabilitation and improvements to the combined sewer system. A summary of the major projects in the OAP is listed below.

Central WWTP – Peak capacity of the plant was increased to 250 million gallons per day (mgd) for secondary treatment along with a wet weather treatment unit capable of providing primary settling and disinfection for an additional 80 mgd flow from the combined sewer system.

Central Pumping Station – A new 160 mgd facility was constructed to pump flow from the combined sewer system to the Central WWTP.

Dry Creek WWTP – Average capacity was increased to 24 mgd and a 14 million gallon (mg) equilization basin was added. A project is currently underway which is expected to increase the peak treatment capacity to 60 mgd and increase the peak capacity of the Dry Creek pumping station to 65 mgd.

Whites Creek WWTP – Average capacity was increased to 37.5 mgd with the ability to handle 75 mgd peak flows. A 10 mg equilization basin was added for temporary storage of excess flow.

Lewis Street Tunnel and Driftwood CSO Detention Basin – A new 8.5 foot diameter tunnel and 5 mg storage basin was constructed to eliminate overflows to Browns Creek and reduce CSO discharges to the Cumberland River.

Demonbreun Separation Project – A new separate sanitary sewer collection system was constructed in the downtown area which eliminated eight combined sewer overflow (CSO) discharge sites and significantly reduced the volume of stormwater entering the combined sewer system.

Second Avenue Tunnel – A new 8.5 foot diameter tunnel was constructed to convey sewage from the Kerrigan sewer, the single largest sewer in the collection system, to the Central Pumping Station.

Downtown CSO Discharge Sites – Completion of the Second Avenue Tunnel reduced the hydraulic loading on the existing 1st Avenue conveyance system and allowed construction of a project to eliminate the discharge from seven downtown CSO overflow points.

Cowan Street and Shelby Park Pumping Stations – Construction of these two new pumping stations removed separate sanitary flows from the combined sewer system and conveys those flows directly to the Central WWTP.

Upgrades to the Central WWTP and the conveyance system have reduced the number of CSO discharge sites from 29 in 1990 to 7 in 2002. In addition, there are two more emergency overflow sites that are designed to remain inactive unless a 1 in 10 year storm event occurs. The remaining active sites include:

- Benedict and Crutcher
- Boscobel
- Driftwood
- Kerrigan
- Schrader Lane
- Van Buren
- Washington

For the purpose of this summary, major pumping stations are defined as those that pump directly to a treatment plant. The major pumping stations and the design capacity for each are listed below by treatment plant.

<u>Central WWTP</u>

- Central CSO P/S — 160 mgd
- Browns Creek P/S — 140 mgd
- Cowan Street P/S — 12.5 mgd
- Shelby Park P/S — 15 mgd
- Stadium P/S — 4 mgd
- 28th Avenue P/S — 20 mgd

Dry Creek WWTP

- Dry Creek P/S 42 mgd
- Old Hickory P/S 4 mgd
- Hendersonville F/M – receives flow from Hendersonville P/S and Mansker Creek P/S with peak flow rates totaling approximately 17 mgd

Whites Creek WWTP

- West Park P/S 60 mgd
- Whites Creek P/S 11.5 mgd
- Bordeaux Hills 2 mgd

The design flow in mgd for each of the treatment plants along with the average daily flow for the last four fiscal years in shown below. The peak daily flow for each facility in the last two years is listed in the last column.

Table II-1. Treatment Plant Flows

Facility	Design Flow	1999	2000	2001	2002	Peak Daily Flow
Central	125	83.0	80.5	77.4	98.1	284
Dry Creek	24	13.3	12.6	13.0	15.0	47
Whites Creek	37.5	31.6	29.2	28.4	30.1	77

The current dry weather flow to each of the wastewater treatment plants is on the order of 50-55% of rated capacity. Future flow projections were identified for each plant during the planning phase of the most recent plant expansion, which was approximately ten years ago. Current plant flows are somewhat below the earlier projections with adequate dry weather capacity available for the next 10-15 years. All three plants are currently hydraulically overloaded during extreme wet weather events. Continued sewer system rehabilitation under the OAP is expected to reduce the peak flows to manageable levels at the Dry Creek and Whites Creek WWTPs. The Central WWTP is designed to maximize treatment plant capacity to reduce overflows from the combined sewer system. The plant will continue to experience maximum hydraulic loading unless extensive sewer system separation is pursued to remove stormwater from the combined sewer system.

A. Central WWTP

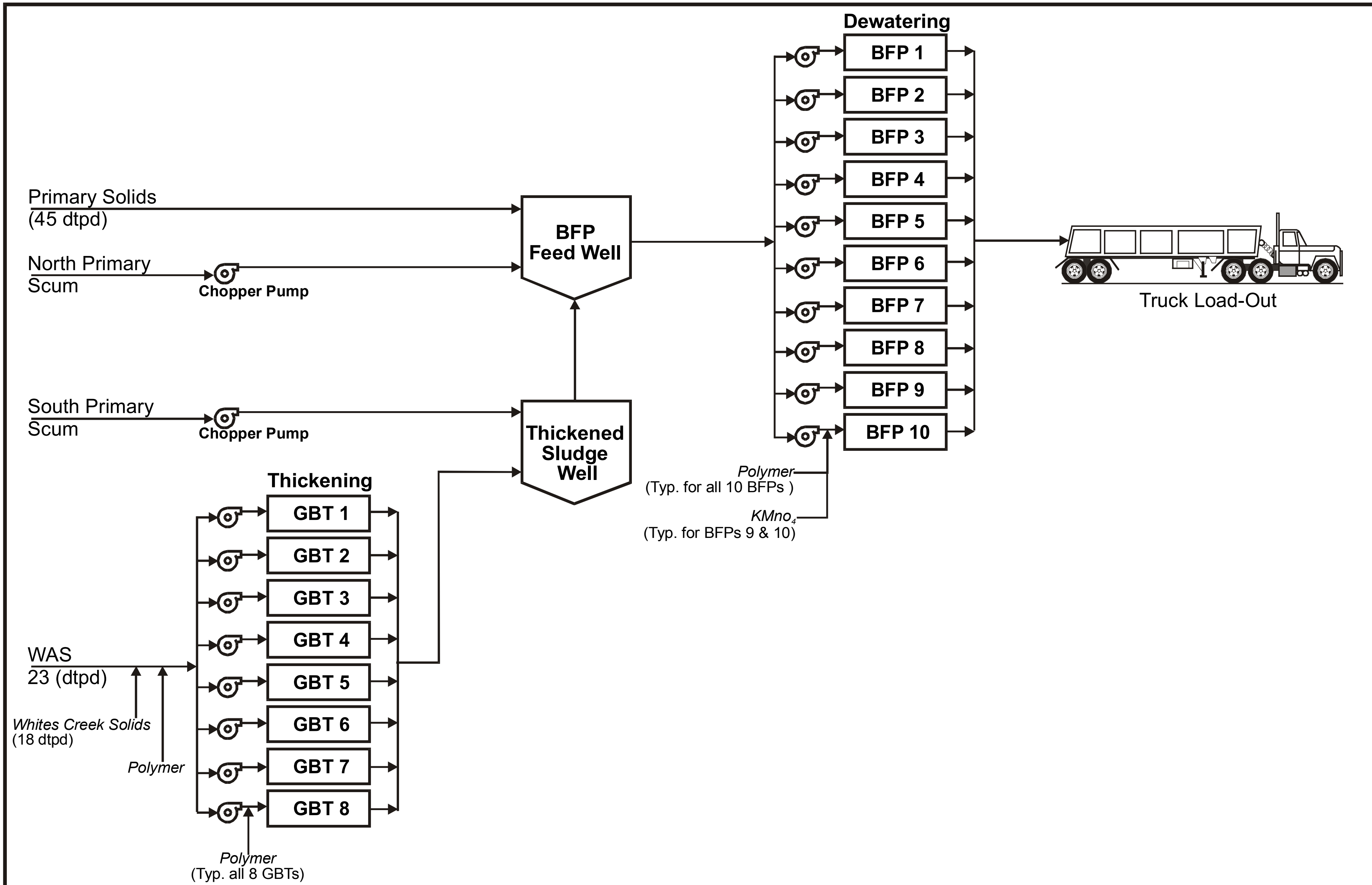
The solids handling processes at Central consist of thickening, liquid storage, and dewatering. The treatment process is presented in Figure II-1. Primary solids are removed from the primary clarifiers and flow by gravity to the belt filter press (BFP) feed well where they are co-mingled with scum pumped from the north primary clarifiers. Waste activated sludge (WAS) is pumped from the final clarifiers to the gravity belt thickener (GBT) feed well where it is combined with WAS and primary solids from Whites Creek. The Whites Creek solids are pumped from Whites Creek to Central at approximately 2 percent solids. The combined Central WAS and Whites Creek solids are thickened using eight GBTs. Polymer is added prior to thickening. The thickened solids from the GBTs are pumped to the BFP feed well where they are combined with primary sludge and scum from the primary clarifiers. The co-mingled primary solids, thickened WAS and scum are pumped to ten belt presses where polymer is added prior to dewatering. The dewatered cake, at approximately 28 percent solids, is conveyed to an open air truck loading area where it is loaded into dump trailers and taken to a private landfill for final disposal. The loading and hauling operation is performed by a private contractor.

Off-site odors from the Central plant have caused complaints from neighbors. Preliminary findings from the ongoing odor study by Jordan, Jones, & Goulding have shown that solids processing is a major source of odors.

B. Whites Creek WWTP

All solids generated at Whites Creek are pumped to Central for dewatering and disposal. The solids treatment processes at Whites Creek are shown in Figure II-2. Waste activated sludge from the Whites Creek final clarifiers is pumped to two dissolved air flotation (DAF) units where polymer is added prior to thickening. Scum and grease from the primary clarifiers is combined with the thickened waste activated sludge (TWAS) in the TWAS well and is then pumped to two storage tanks. Primary solids from the primary clarifiers are also pumped to the storage tanks, where they are combined with the TWAS and scum. The mixture has a solids concentration of approximately 2 percent. The co-mingled solids are pumped via pipeline approximately 5.5 miles to the GBT feed well at Central for additional thickening. The solids are pumped continuously until the storage tanks are drawn down to desired levels. The pipeline is then flushed with plant water from Whites Creek.

Prior to 1997, Whites Creek solids were dewatered at Whites Creek using three belt filter presses. The BFPs, which are still at Whites Creek, have been cannibalized for repair



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**NASHVILLE
CENTRAL WWTP
CURRENT SOLIDS HANDLING SYSTEM**

Figure II-1

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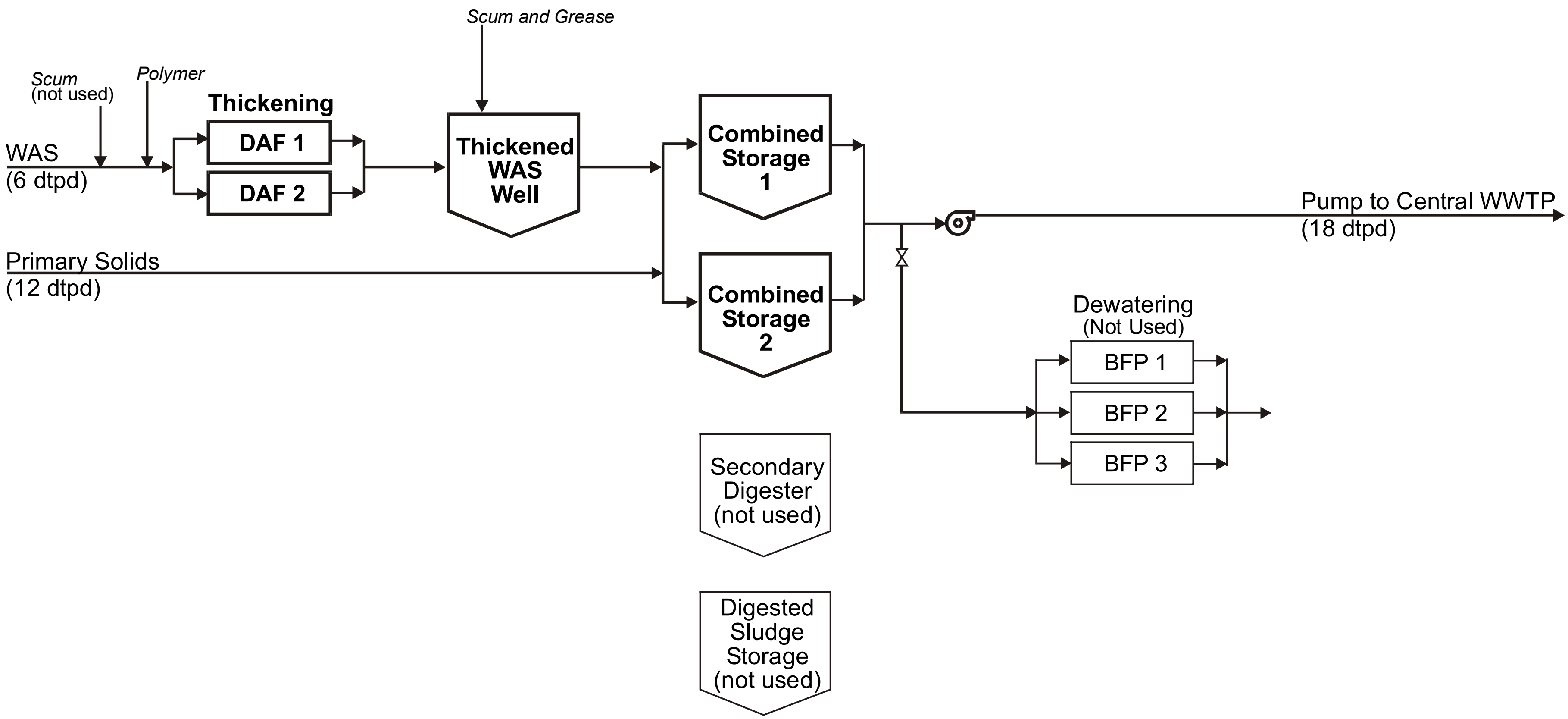

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NASHVILLE
WHITES CREEK WWTP
CURRENT SOLIDS HANDLING SYSTEM

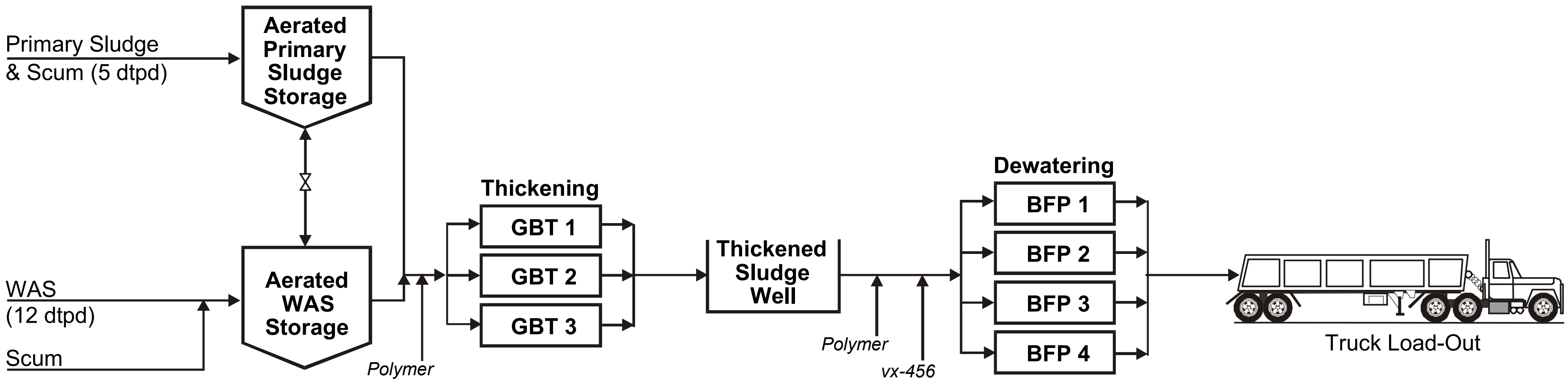
Figure II-2

69979.100-SHc ADI 9/12/02

parts for presses at Central and are no longer operational. Existing anaerobic digester tankage is being used to store the combined TWAS and primary solids. Of the four tanks in the digester complex, two are used for storage. The remaining two tanks have been abandoned in place.

C. Dry Creek WWTP

Dry Creek solids treatment includes thickening, liquid storage, and dewatering prior to landfill disposal. The solids treatment processes at Dry Creek are shown in Figure II-3. Primary solids and scum removed from the primary clarifiers are pumped to the primary sludge storage tank. Waste activated sludge and scum from the final clarifiers are pumped to the WAS storage tank for thickening. Both storage tanks are modified anaerobic digesters and are equipped with coarse bubble aeration. The existing pipe and valve configuration allows solids transfer between the two tanks. Waste activated sludge is pumped from the WAS storage tank to three GBTs. Polymer is added prior to thickening. The primary solids are pumped from the primary sludge storage tank to the TWAS well, where they are combined with the TWAS. The co-mingled solids are then pumped to four BFPs, where polymer and VX-456 are added prior to dewatering to approximately 28 percent solids. The dewatered cake is conveyed to an open-air truck load out area, where it is loaded into dump trucks for landfill disposal. The loading and hauling operations are performed by a private contractor.



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NASHVILLE
DRY CREEK WWTP
CURRENT SOLIDS HANDLING SYSTEM

Figure II-3

69979.100-SHb ADI 2/19/02

III. BIOSOLIDS CHARACTERISTICS

A. Quantity

The solids quantities generated at the Central, Whites Creek, and Dry Creek plants are listed in Table III-1. Total solids values for all three plants were based on Central and Dry Creek data from January 1999 through September 2001. Since Whites Creek solids have been pumped to Central for treatment since 1997, recent Central data reflect combined solids quantities from both Central and Whites Creek. Central solids records from 1994 through 1996 were available. The “pre-Whites Creek” and “post-Whites Creek” data were compared to estimate relative contributions from each plant. The resulting contribution ratios were applied to the 1999 – 2001 data to generate solids quantities for each plant. Dry Creek plant data identified primary solids and WAS quantities in addition to total solids quantities.

Central and Whites Creek data reported total solids but did not identify primary solids and WAS quantities. Therefore, Central and Whites Creek primary solids and WAS quantities were estimated based on their reported ratios at Dry Creek. Conventional activated sludge plants with primary clarification typically produce similar quantities of primary solids and WAS. However, the values reported at Dry Creek show a two to one primary solids to WAS ratio. Metro staff performed an independent evaluation of solids production, confirming the reported primary solids and WAS ratios at all plants.

Growth projections were based on a 20-year project life. An annual growth rate of one percent was applied to the current solids quantities, based on the City’s population projections. The projected solids quantities are also presented in Table III-1.

Table III-1. Plant Solids Estimates (dtpd)

Current Conditions				
	Primary	**WAS**	**Annual**	**Max Month**
Central	45	23	68	88
Whites Creek	12	6	18	23
Dry Creek	12	5	17	22
TOTAL			103	133
Future Conditions				
	Primary	**WAS**	**Annual**	**Max Month**
Central	55	28	83	108
Whites Creek	14	8	22	29
Dry Creek	14	7	21	27
TOTAL			126	164

B. Quality

Solids produced at the Metro Water Services wastewater treatment plants are sampled monthly and analyzed for criteria identified in 40 CFR Parts 258, 268, and 503. Based on information presented in the 1998 through 2000 Part 503 annual reports, the Metro Water Services solids met the ceiling concentration limits (CCL) for beneficial use. However, a single composite sample collected in June 1998 from combined Central and Whites Creek solids exceeded the most restrictive pollutant concentration limit (PCL) for arsenic. This PCL must be met for the solids to be distributed or marketed to the public without limits on loading rates. Several other composite samples collected at both Central and Dry Creek during the 1998 through 2000 period show arsenic levels that are at or near the PCL of 41 mg/Kg. Class A biosolids that exceed the PCL, but meet the CCL, can be sold or given away or bulk land applied. However, the generator must calculate and record annual pollutant loading rates or cumulative pollutant loading rates (depending on the quantity of biosolids applied) and provide these values to the user. If Metro Water Services pursues beneficial reuse, arsenic contributions to the wastewater plant should be addressed to ensure that the biosolids meet all PCLs, minimizing management and reporting requirements.

If Metro Water Services elects to beneficially reuse biosolids, additional analyses will be required. USEPA stipulates that total nitrogen, total Kjeldahl nitrogen, nitrate nitrogen, and ammonia nitrogen must be calculated and provided to the user. Since an increasing number of states also regulate phosphorus application, phosphorus analysis will be needed. While the regulations do not currently require analysis for dioxins, proposed amendments have been published that will limit dioxin concentrations in land applied biosolids to fewer than 300 parts per trillion toxicity equivalents (TEQs).

IV. ALTERNATIVE EVALUATION

The most promising biosolids management alternatives were identified through a screening process. The screening process, which occurred in Workshop #1 and Workshop #2, is described in more detail in the Appendix. The initial screening in Workshop #1 focused on biosolids management and included:

- No action.
- Land application.
- Distribution and marketing of Class A biosolids products.
- Landfilling (of dewatered solids or incinerator ash).
- Conversion to or use in commercial products, such as *Minergy* glass aggregate.
- Conversion to or use as a fuel product, such as *Primenergy* sludge-to-energy or gas process.

The management practices that were selected as the most promising, based on suitability to Metro Water Services sites and constraints, were distribution and marketing of Class A biosolids (D&M) and landfilling.

A second screening process was then performed on the technologies currently available to support these practices. The technologies remaining after the screening were investigated to determine equipment, facility requirements, and disposal quantities. In addition to the no action option of continuing the current process of landfilling raw, dewatered solids, the following five management practices/technologies were identified for investigation:

- Distribution and Marketing:
  - Alkaline Stabilization.
  - Composting.
  - Heat Drying (raw or digested solids).
- Landfilling:
  - Anaerobic Digestion.
  - Incineration.

Following Workshop #1, each of these management practice combinations was evaluated for each plant - Central, Whites Creek, and Dry Creek - to determine site requirements, solids generation, storage requirements, and process equipment requirements. All possible permutations combining these five treatment technologies at the three wastewater treatment plants were examined and a reduced list of 26 alternatives was developed for evaluation in Workshop #2. This evaluation and its results are presented in Appendix A, along with the alternatives listing. In Workshop #2, the project team identified the best-suited management practice/technology combinations for Metro Water Services, reducing the previous list of treatment alternatives from 26 to 4. Three of the four selected alternatives were modified slightly from their original configuration. The selected combinations were then evaluated based on economic and non-economic criteria.

The evaluated alternatives are listed in Table IV-1 (alternative numbers match descriptions in Appendix A):

Table IV-1. Treatment Alternatives Selected for Additional Evaluation

Alt No.	Central	Whites Creek	Dry Creek
10	Landfill raw, dewatered biosolids	Pump raw, thickened biosolids to Central	Landfill raw, dewatered biosolids
13 (mod)	Landfill digested, dewatered biosolids	Pump digested biosolids to Central	Landfill digested, dewatered biosolids
4a	Heat dry digested, dewatered biosolids	Pump raw, thickened biosolids to Central	Landfill digested, dewatered biosolids
19 (mod)	Heat dry digested, dewatered biosolids	Pump digested biosolids to Central	Heat dry digested, dewatered biosolids

A. Description of Treatment Alternatives

All treatment alternatives selected during the screening process will provide solids treatment at Central and Dry Creek. All alternatives will also use pipeline transfer of solids from Whites Creek to Central, minimizing solids treatment at Whites Creek. The treatment alternatives are described below:

1. No Action

The existing solids handling facilities and equipment at the Central WWTP are at the end of their useful life. The existing Thickening Building is severely corroded and poorly ventilated. The thickening equipment is maintenance intensive due to its age. The belt filter presses are located in the Incinerator Building and the Ash Silo Building. The equipment is in poor mechanical condition due to its age. It is common for two of the BFPs to be out of service for repairs. The dewatering equipment is located on different floors in three different buildings making operations difficult. Neither the Incinerator Building nor the Ash Silo Building has odor control systems. These facilities have been identified as significant sources of off-site odors.

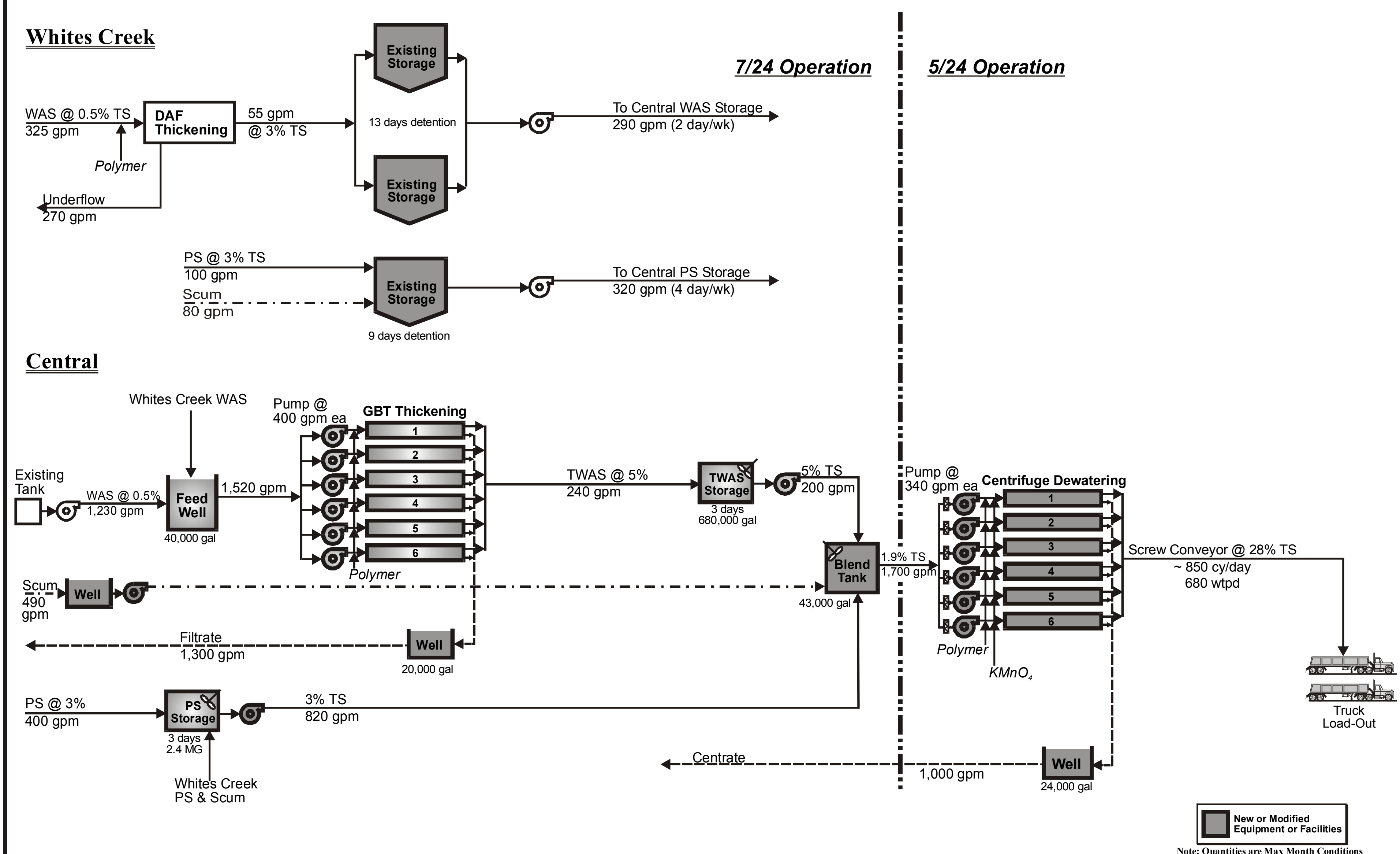
For these reasons, the No Action alternative is not an option. The existing solids handling facilities cannot be relied on to thicken and dewater the raw sludge through the planning period.

2. Alternative 10 – Landfill Raw, Dewatered Solids from Central and Dry Creek, Pump Raw Thickened Solids from Whites Creek to Central

This alternative will provide treatment and disposal processes that are similar to those currently used at the three plants; however, it will include new process equipment and facilities to address storage, odor, and handling issues. Treatment schematics for this alternative are shown in Figures IV-1a and b.

Central. Primary solids will be removed from the primary clarifiers seven days per week and pumped to a new primary sludge storage tank equipped with jet mixing. This storage tank will also receive primary sludge and scum from Whites Creek, via a new pipeline. Waste activated sludge removed from the final clarifiers will be thickened using six new gravity belt thickeners. The GBT feed well will also receive thickened WAS from Whites Creek, via the existing pipeline. Flushing water, which will be sent through the pipelines after pumping is completed, will be diverted to the GBT filtrate well for return to the head of the plant. After thickening, TWAS will be combined with primary sludge and scum from the primary and final clarifiers in a blend tank prior to dewatering. Six new high solids centrifuges will be used to dewater the combined raw solids. Polymer and potassium permanganate will be added immediately upstream of dewatering. Dewatered cake will be transferred to the truck load-out area via screw conveyors. All hauling and disposal will be performed by contract operation.

This alternative will include a new thickening and dewatering building, with an enclosed 2-bay truck load-out area, sited to the east and across the street from the existing dewatering building. All processes associated with primary solids - storage tanks, blend tank, dewatering, and truck load-out – will be enclosed to minimize odors. In addition, centrifuge dewatering will be used to contain odors from the raw solids, minimizing odor potential in the dewatering area. Odor control will be provided for the storage tanks, thickening, dewatering, and truck load-out facilities. Primary sludge and TWAS storage



NASHVILLE
ALTERNATIVE 10-WHITES CREEK & CENTRAL FACILITIES
LANDFILL RAW, DEWATERED BIOSOLIDS

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Figure IV-1a

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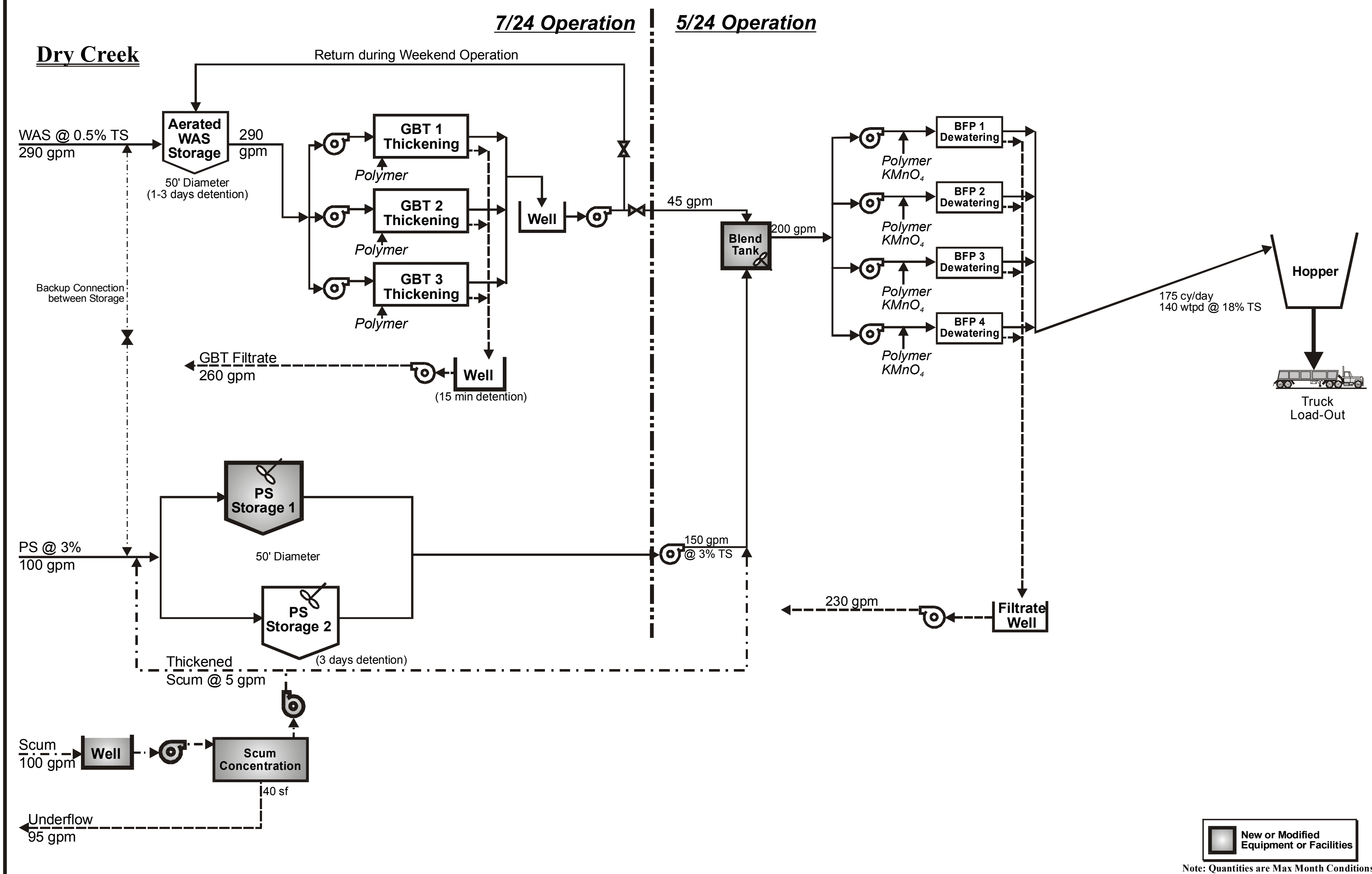

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NASHVILLE
ALTERNATIVE 10-DRY CREEK FACILITY
LANDFILL RAW, DEWATERED BIOSOLIDS

Figure IV-1b

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will provide transition between the 7-day per week sludge removal operation from the liquid treatment process and the 5-day per week sludge dewatering and disposal operation. Projected chemical use and storage requirements are based on plant reported values using current chemicals and dosages. This alternative will require the following new facilities or modifications to existing facilities:

- Solids handling building for thickening and dewatering operations:
  - Six new gravity belt thickeners.
  - Six high solids dewatering centrifuges.
  - Polymer feed and storage for thickening and dewatering.
  - Potassium permanganate feed and storage.
- New covered thickened WAS storage tankage.
- New covered primary solids storage.
- Blend tank upstream of dewatering.
- New truck load-out facilities.
- Screw conveyors to transfer dewatered cake to truck loading equipment.
- Odor control for thickening and dewatering facilities, including truck load out area.

Whites Creek. Waste activated sludge will be removed from the final clarifiers on a 7-day per week basis and thickened through existing dissolved air flotation (DAF) units. The thickened WAS will then be pumped to two of the four tanks in the existing digester complex, which will be retrofit to provide covered TWAS storage. The TWAS will be pumped to the GBT feed well at Central for additional thickening and dewatering via the existing pipeline. The number of days per week that TWAS will be pumped to Central will be determined by the solids concentration of thickened sludge. Primary solids and scum will be removed from the clarifiers seven days per week and stored in one of the existing digester tanks, which will be retrofit for storage use. The combined primary solids and scum will be pumped to the primary storage tank at Central via a new pipeline, parallel to the existing pipeline. Odor control will be provided for the retrofit storage tanks. This alternative will require the following new facilities or modifications to existing facilities:

- Conversion of three existing digester tanks to separate primary solids and thickened WAS storage.
- Odor control for solids storage tanks.
- New 8-inch pipeline from Whites Creek to Central.

Dry Creek. The WAS storage and thickening processes will remain virtually unchanged at Dry Creek. Modifications will be limited to the scum handling, primary sludge storage, and sludge blending processes. A third storage tank will be added to the existing 2-tank storage complex to increase primary sludge storage. The new tank will be the same size as the existing tanks; however, it will be equipped with mechanical mixing, rather than the diffused air mixing in the existing tanks. Two of the three tanks will be used for primary sludge storage. The diffused aeration in the existing primary sludge storage tank will be removed and replaced with mechanical mixing. The diffused air mixing in the WAS storage tank will remain unchanged. Odor control will be provided for the new storage tank. A pipeline will be added to divert TWAS back to the WAS storage tank when dewatering is not in operation; this will increase effective WAS storage and will allow the GBTs to operate seven days per week and the downstream BFPs to operate five days per week. A new blend tank will be added upstream of the BFPs to blend TWAS and primary sludge prior to dewatering on the existing BFPs. Projected chemical use and storage requirements are based on plant reported values using current chemicals and dosages. An allowance has been included to replace two of the existing four BFPs during the project life.

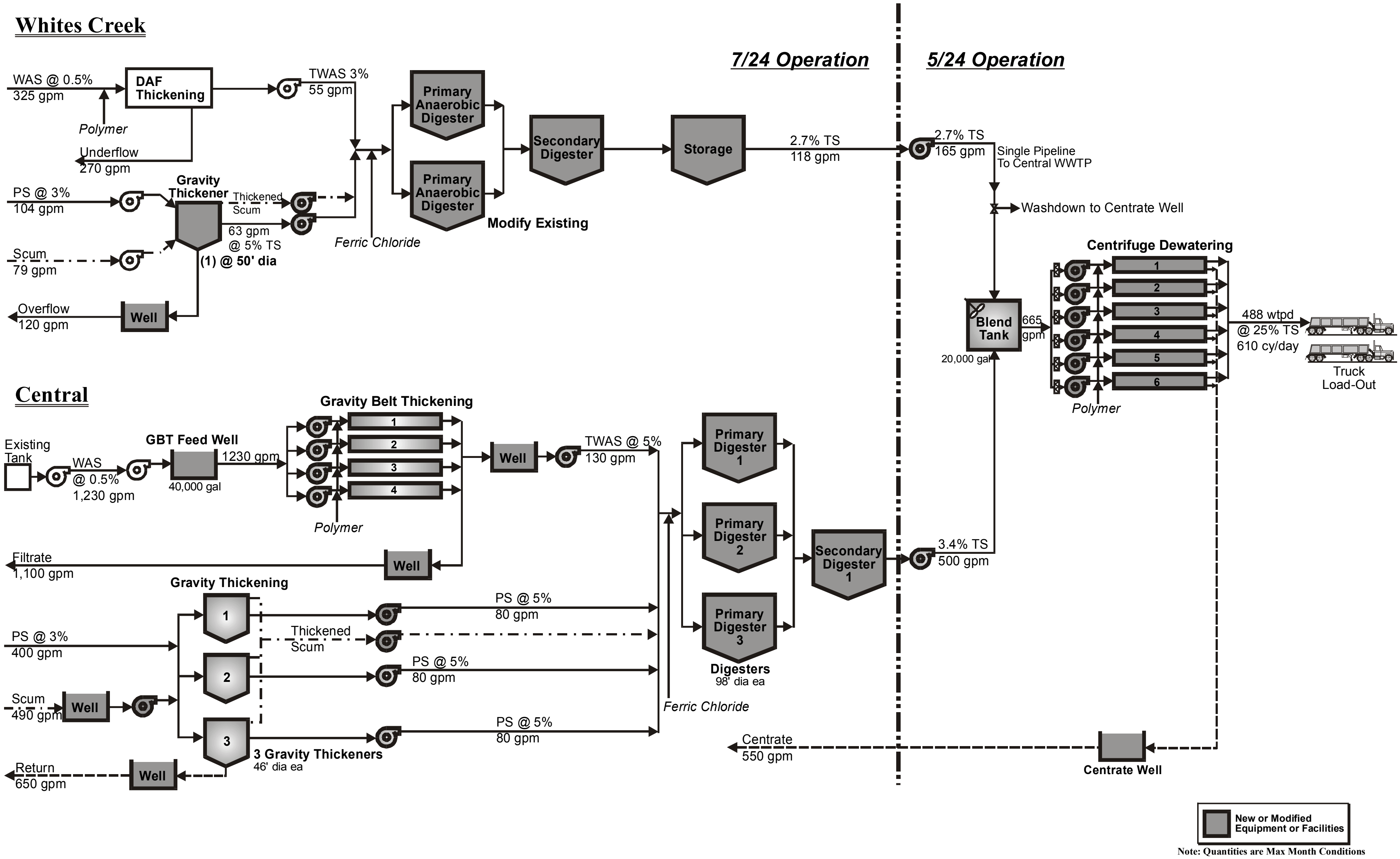
Scum handling will be modified to eliminate co-thickening with WAS. Scum from the primary and secondary clarifiers will be pumped to a new package DAF unit for thickening. Thickened scum will then be combined with the primary sludge in the primary sludge storage tanks. This alternative requires the following new facilities or modifications to existing facilities:

- New primary solids storage tank.
- Replacement of diffused air mixing system in existing primary solids storage tank with mechanical mixing.
- Dissolved air flotation facility for scum thickening.
- Blend tank upstream of dewatering.
- Allowance to replace two existing belt filter presses during project life.

3. Alternative 13 (modified) – Landfill Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

This alternative will provide stabilization through anaerobic digestion to minimize odors and reduce solids quantities. It will also include new treatment equipment and solids handling facilities. Treatment schematics for this alternative are shown in Figures IV-2a and IV-2b.

Central. The new solids handling and treatment facilities will be located on the 8-acre vacant lot across 2nd Avenue North from the existing Sludge Disposal and Ash Buildings. Primary solids will be removed from the primary clarifiers and thickened prior to anaerobic digestion using three new, covered gravity thickeners. Scum from the primary



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NASHVILLE
ALTERNATIVE 13 (MODIFIED)-WHITES CREEK & CENTRAL FACILITIES
LANDFILL DIGESTED, DEWATERED BIOSOLIDS

Figure IV-2a

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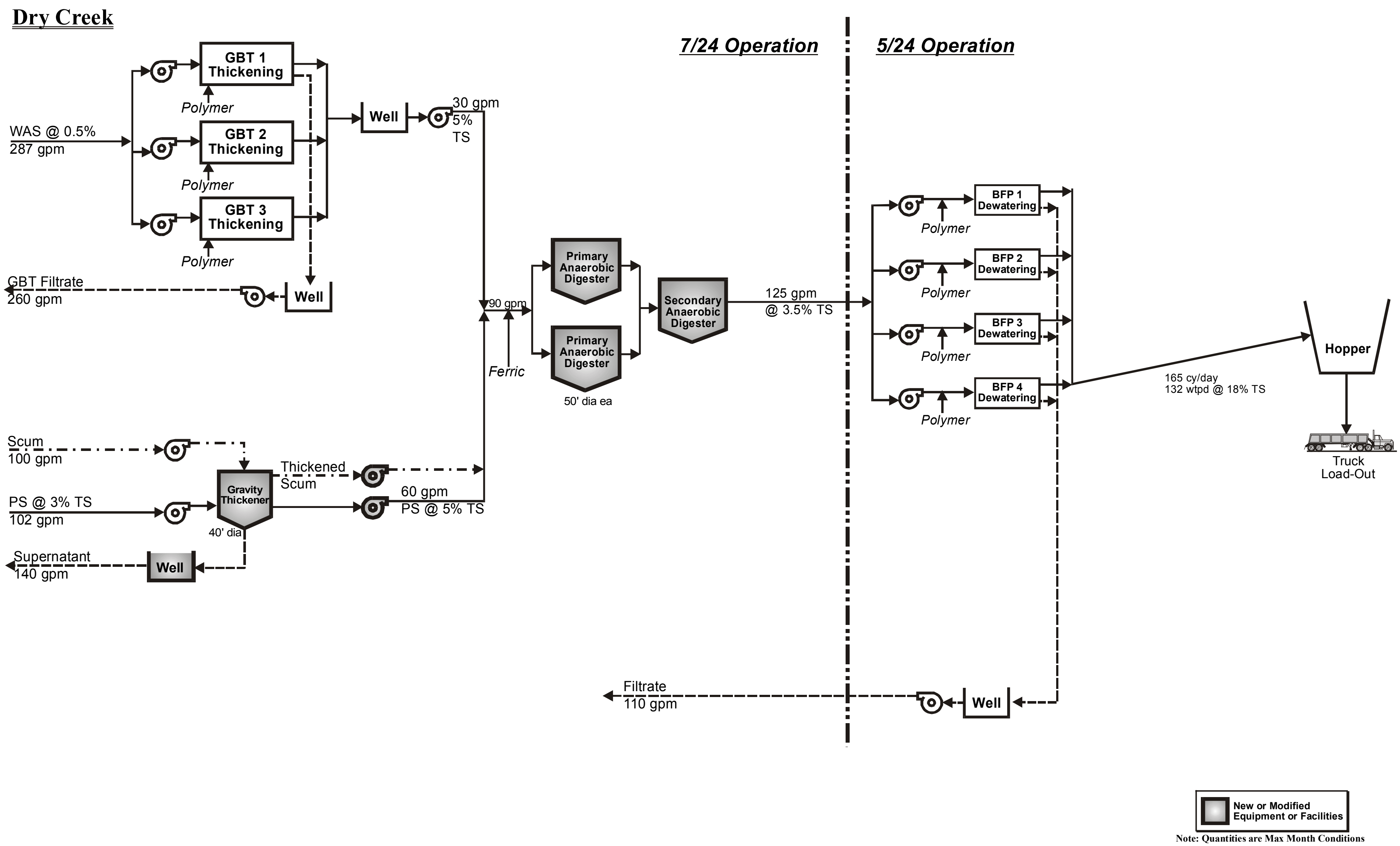

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NASHVILLE
ALTERNATIVE 13 (MODIFIED)-DRY CREEK FACILITY
LANDFILL DIGESTED, DEWATERED BIOSOLIDS

Figure IV-2b

69979.100-1d MB ADI 9/12/02

and secondary clarifiers will also be routed to the gravity thickeners for thickening. The gravity thickeners will be equipped with skimming devices to collect thickened scum. The thickened primary solids and scum will be conveyed through separate pipelines to three new primary anaerobic digesters. Waste activated sludge will be thickened through four new gravity belt thickeners. Thickened WAS will be pumped to the new primary digesters, where it will be mixed with the thickened primary solids and scum. The anaerobic digestion complex will consist of three primary digesters and one secondary digester. Digester gas will be flared, but the potential exists for energy recovery using the gas. Ferric chloride feed and storage equipment will be provided so that iron salts can be added to prevent struvite formation. Digested solids will be pumped to a blend tank, where digested solids from Whites Creek will be introduced. The digested solids will be dewatered through six new high solids centrifuges and transferred to the truck load-out area via screw conveyors. All hauling and disposal will be performed by contract operation.

This alternative will include a new thickening and dewatering building, with an enclosed 2-bay truck load-out area, sited to the east, across the street from the existing dewatering building. All processes associated with solids – gravity thickeners, blend tank, dewatering, and truck load out – will be enclosed to minimize odors. Odor control will be provided for the gravity thickeners, GBT area, dewatering, and truck load-out facilities. Storage in the primary and secondary digesters will provide transition between the seven day per week sludge removal operation from the liquid treatment process and the five day per week sludge dewatering and disposal operation. The projected polymer and iron use and storage requirements are based on typical values and reflect the Mannich polymer currently in use at Central. This alternative will require the following new facilities or modifications to existing facilities:

- Solids handling building for thickening and dewatering operations:
  - Four new gravity belt thickeners.
  - Six high solids dewatering centrifuges.
  - Polymer feed and storage for thickening and dewatering.
- New primary scum pumping equipment.
- Three 48-foot diameter gravity thickeners with surface skimming and covers.
- Three 98-foot diameter primary and one 98-foot diameter secondary anaerobic digesters.
- Ferric feed and storage for struvite control.
- Blend tank upstream of dewatering.
- New truck load-out facilities.
- Screw conveyors to transfer dewatered cake to truck loading equipment.
- Odor control for thickening and dewatering facilities, including truck load out area.

Whites Creek. Waste activated sludge will be removed from the final clarifiers seven days per week and thickened through existing dissolved air flotation (DAF) units. The thickened WAS will then be pumped to the existing anaerobic primary digesters, which will be retrofited with new mixing and heating equipment and covers. Primary solids and scum will be removed from the clarifiers seven days per week and thickened through a new, covered gravity thickener. The thickened scum and primary solids will be pumped to the primary digesters, where they will be mixed with the TWAS. The digestion complex will include two primary digesters, one secondary digester, and one storage tank (all existing tankage) refurbished with new covers, mixing, heating, and gas collection to support anaerobic digestion. Ferric chloride feed and storage equipment will be provided so that iron salts can be added to prevent struvite formation. The digested solids will be pumped via the existing pipeline to the blend tank at Central for dewatering and disposal.

This alternative provides odor control for the covered gravity thickeners. Gas from the digesters will be flared; however, potential opportunities exist for co-generation with the adjacent landfill gas co-gen operation. Iron salt use and storage requirements are based on typical values. This alternative will require the following new facilities or modifications to existing facilities:

- One 50-foot diameter gravity thickener with surface skimming and cover.
- Conversion of existing anaerobic digester tanks to provide two primary digesters, one secondary digester and one storage tank.
- Ferric feed and storage for struvite control.
- Replacement of sections of existing pipeline from Whites Creek to Central where corrosion is known to exist.

Dry Creek. The Dry Creek solids handling process will include separate thickening for primary sludge and WAS, anaerobic digestion, and dewatering. A new, covered gravity thickener will be used to thicken primary solids and scum from the primary and secondary clarifiers. Odor control will be provided for the gravity thickener. After thickening, the primary solids and scum will be pumped to anaerobic digestion, which will consist of two primary digesters and a secondary digester. Two of the three tanks in the digester complex will be refurbished tanks, previously used for aerated sludge storage, retrofited to include new covers, mixing heating, and gas storage. Ferric chloride feed and storage equipment will be provided so that iron salts can be added to prevent struvite formation. The new, third tank will be co-located with the two existing tanks and will be the same size as the existing tanks. The WAS thickening process will remain similar to the current operation and will continue to use the existing GBTs. However, the GBTs will be operated seven days per week and TWAS will be pumped to the digesters where it will be combined with the primary solids. Storage volume in the digestion process will provide transition between the seven day per week thickening operation and the five day per week dewatering operation. The projected polymer and iron use and storage requirements are based on typical values and reflect the Mannich polymer currently in use at Dry Creek. An allowance has been included to replace two of the existing four belt filter presses during the project life. This alternative will require the following new facilities or modifications to existing facilities:

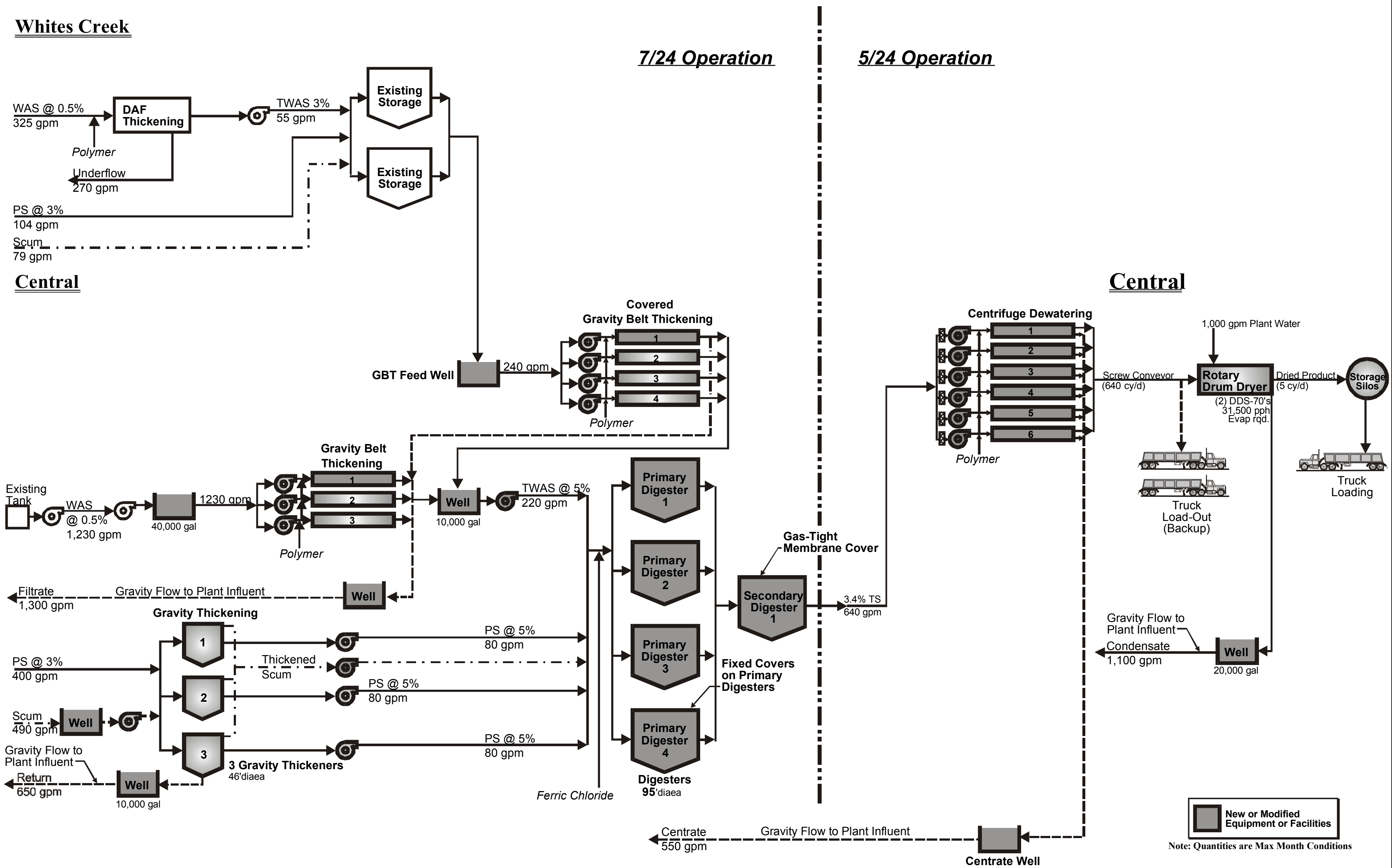
- One 40-foot diameter gravity thickener with surface skimming and cover.
- Conversion of existing storage tanks to provide two primary digesters.
- Construction of 50-foot diameter secondary digester.
- Ferric feed and storage for struvite control.
- Allowance to replace two existing belt filter presses during project life.

4. Alternative 4a – Heat Dry Digested, Dewatered Solids from Central, Pump Raw Thickened Solids from Whites Creek to Central, Landfill Digested, Dewatered Solids from Dry Creek

This alternative will use anaerobic digestion at Central and Dry Creek to minimize odors and reduce solids quantities. It will include new treatment processes, digestion, and solids handling facilities at Central and digestion equipment at Dry Creek. In this option, no changes will be made to the existing Whites Creek equipment or treatment processes – raw, combined primary and WAS solids will be pumped to Central for digestion, dewatering, and heat drying. Landfilling of dewatered solids from Dry Creek will reduce total capital requirements for this treatment alternative when compared to the heat drying provided for Alternative 19 (modified), but will still allow beneficial use of solids generated at Central and Whites Creek. Treatment schematics for this alternative are shown in Figures IV-3a and IV-3b.

Central. The modifications at Central will include new gravity thickening for primary solids and gravity belt thickening for WAS generated at Central. It will also include enclosed gravity belt thickening for the combined primary solids and WAS pumped from Whites Creek. The thickened Whites Creek solids will be combined with the thickened Central solids and anaerobically digested, followed by centrifuge dewatering, and heat drying. This alternative will require the following new facilities or modifications to existing facilities:

- Solids handling building for thickening and dewatering operations:
  - Three new (open) 2-meter gravity belt thickeners for Central WAS.
  - Four new enclosed 2-meter gravity belt thickeners for Whites Creek solids.
  - Six high solids dewatering centrifuges.
  - Two-unit rotary drum dryer system.



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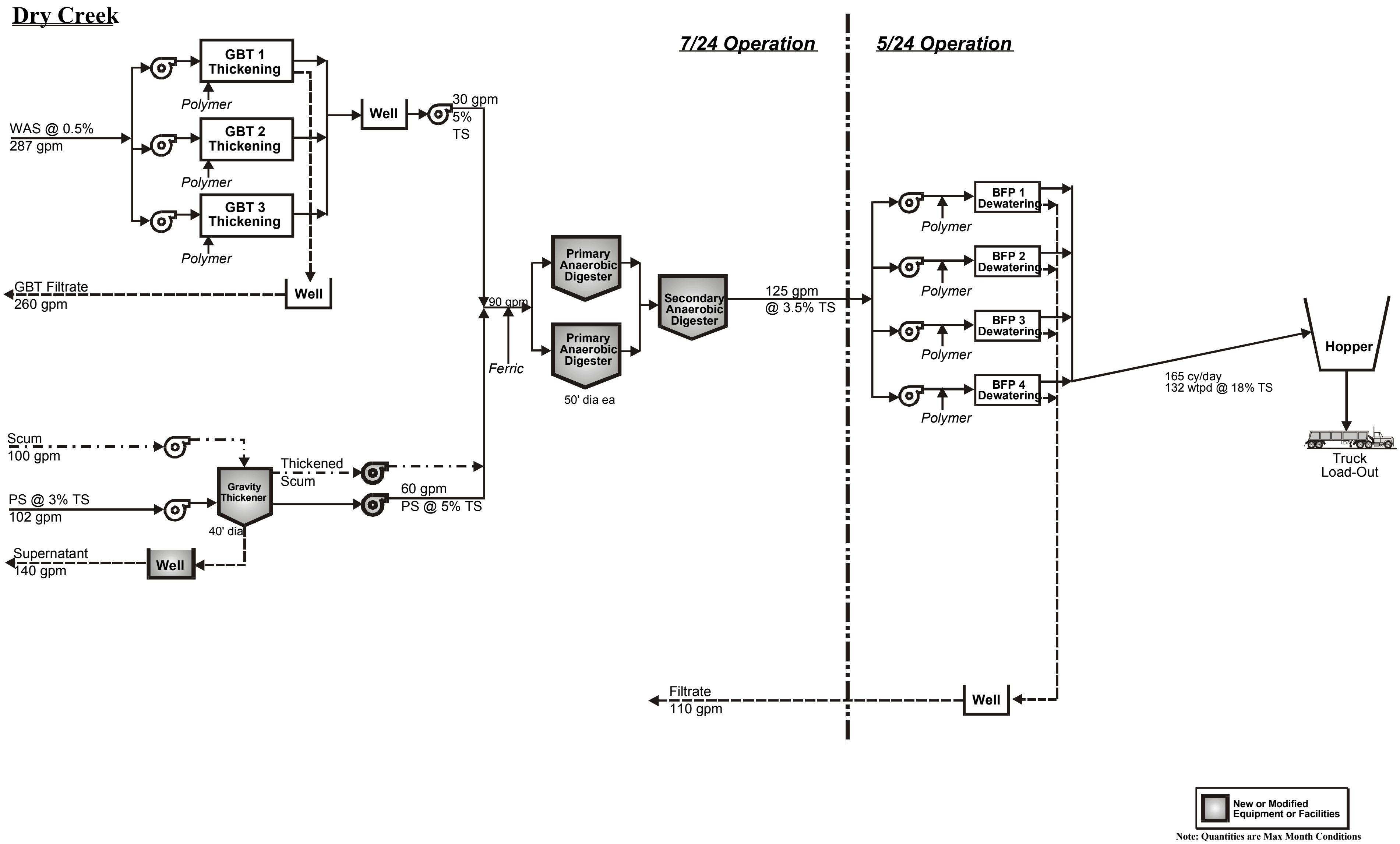
NASHVILLE
ALTERNATIVE 4a
ALL DIGESTION PERFORMED AT CENTRAL

Figure IV-3a



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NASHVILLE
ALTERNATIVE 4a
LANDFILL DIGESTED, DEWATERED BIOSOLIDS

Figure IV-3b

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- Polymer feed and storage for thickening and dewatering.

- New primary scum pumping equipment.
- Three 46-foot diameter gravity thickeners with surface skimming and covers.
- Four 95-foot diameter primary and one 95-foot diameter secondary anaerobic digesters.
- Ferric feed and storage for struvite control.
- New truck load-out facilities.
- Screw conveyors to transfer dewatered cake to drying and/or truck loading equipment.
- Odor control for thickening and dewatering facilities, including truck load out area.

Whites Creek. Waste activated sludge will be removed from the final clarifiers on a 7-day per week basis and thickened through existing dissolved air flotation (DAF) units. The thickened WAS will then be pumped to two of the four tanks in the existing digester complex, currently used for primary and TWAS solids storage. The combined solids will be pumped to a dedicated GBT feed well at Central for additional thickening via the existing pipeline. The number of days per week that TWAS will be pumped to Central will be determined by the solids concentration of thickened sludge. This alternative will require no new facilities; however, it includes replacement of sections of the existing pipeline from Whites Creek to Central where corrosion is known to exist.

Dry Creek. This alternative will add anaerobic digestion and primary solids thickening to the current treatment processes. Equipment and operations of this alternative are identical to Alternative 13 (modified). The thickening and digestion equipment will be operated seven days per week with dewatering and disposal operated five days per week. This alternative will require the following new facilities or modifications to existing facilities:

- One 40-foot diameter gravity thickener with surface skimming and cover.
- Conversion of existing storage tanks to provide two primary digesters.
- Construction of 50-foot diameter secondary digester.
- Ferric feed and storage for struvite control.
- Allowance to replace two existing belt filter presses during project life.

5. Alternative 19 (modified) – Heat Dry Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

This alternative will use anaerobic digestion at Whites Creek, Central, and Dry Creek prior to dewatering and drying to minimize odors, reduce solids quantities, and ensure high-quality dried product. All dewatering and drying of Whites Creek solids will be performed at Central. This alternative will provide the highest level of treatment for all solids generated by Metro Water Services and will support beneficial use of all biosolids. Treatment schematics are shown in Figures IV-4a and b.

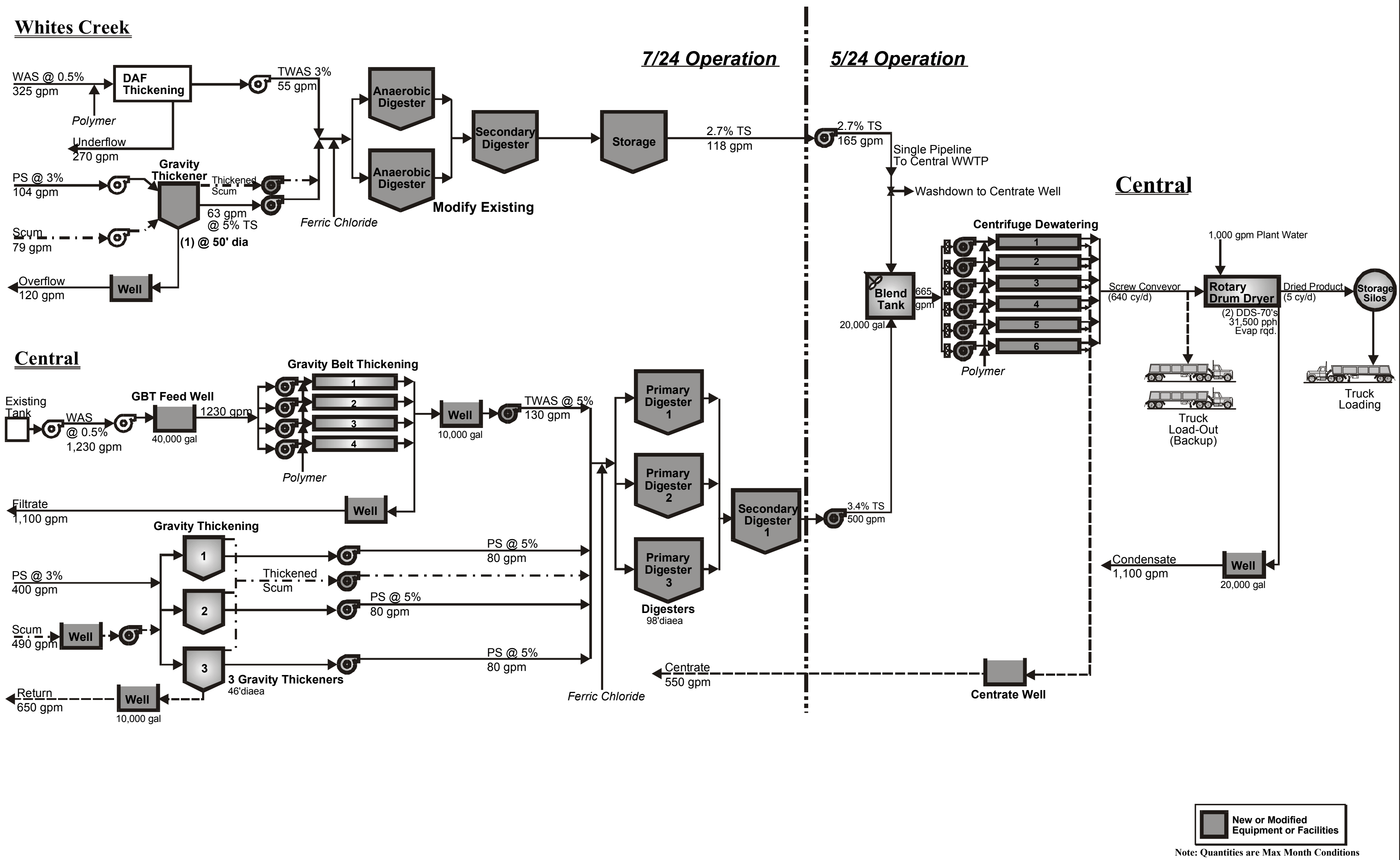
Central. The modifications at Central will include new gravity thickening for primary solids, gravity belt thickening for WAS, anaerobic digestion, centrifuge dewatering, and heat drying. This alternative will require the following new facilities or modifications to existing facilities:

- Solids handling building for thickening, dewatering, and drying operations:
  - Four new gravity belt thickeners.
  - Six high solids dewatering centrifuges.
  - Polymer feed and storage for thickening and dewatering.
  - Two-unit rotary drum dryer system.
- New primary scum pumping equipment.
- Three 46-foot diameter gravity thickeners with surface skimming and covers.
- Three 98-foot diameter primary and one 98-foot diameter secondary anaerobic digesters.
- Ferric feed and storage for struvite control.
- Blend tank upstream of dewatering.
- New truck load-out facilities.
- Screw conveyors to transfer dewatered cake to drying and/or truck loading equipment.
- Odor control for thickening and dewatering facilities, including truck load out area.

Whites Creek. The modifications at Whites Creek will include new gravity thickening and anaerobic digestion. This alternative will require the following new facilities or modifications to existing facilities:

- One 50-foot diameter gravity thickener with surface skimming and cover.
- Conversion of existing anaerobic digester tanks to provide two primary digesters, one secondary digester and one storage tank.
- Ferric feed and storage for struvite control.
- Replacement of sections of existing pipeline from Whites Creek to Central where corrosion is known to exist.

Dry Creek. This alternative will add heat drying to digestion and dewatering modifications described in Alternative 13 (modified). Equipment and operations of this alternative are similar to Alternative 13 (modified); however, new drying and product



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ALTERNATIVE 19 (MODIFIED)-WHITES CREEK & CENTRAL FACILITIES
HEAT DRY DIGESTED BIOSOLIDS

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Figure IV-4a

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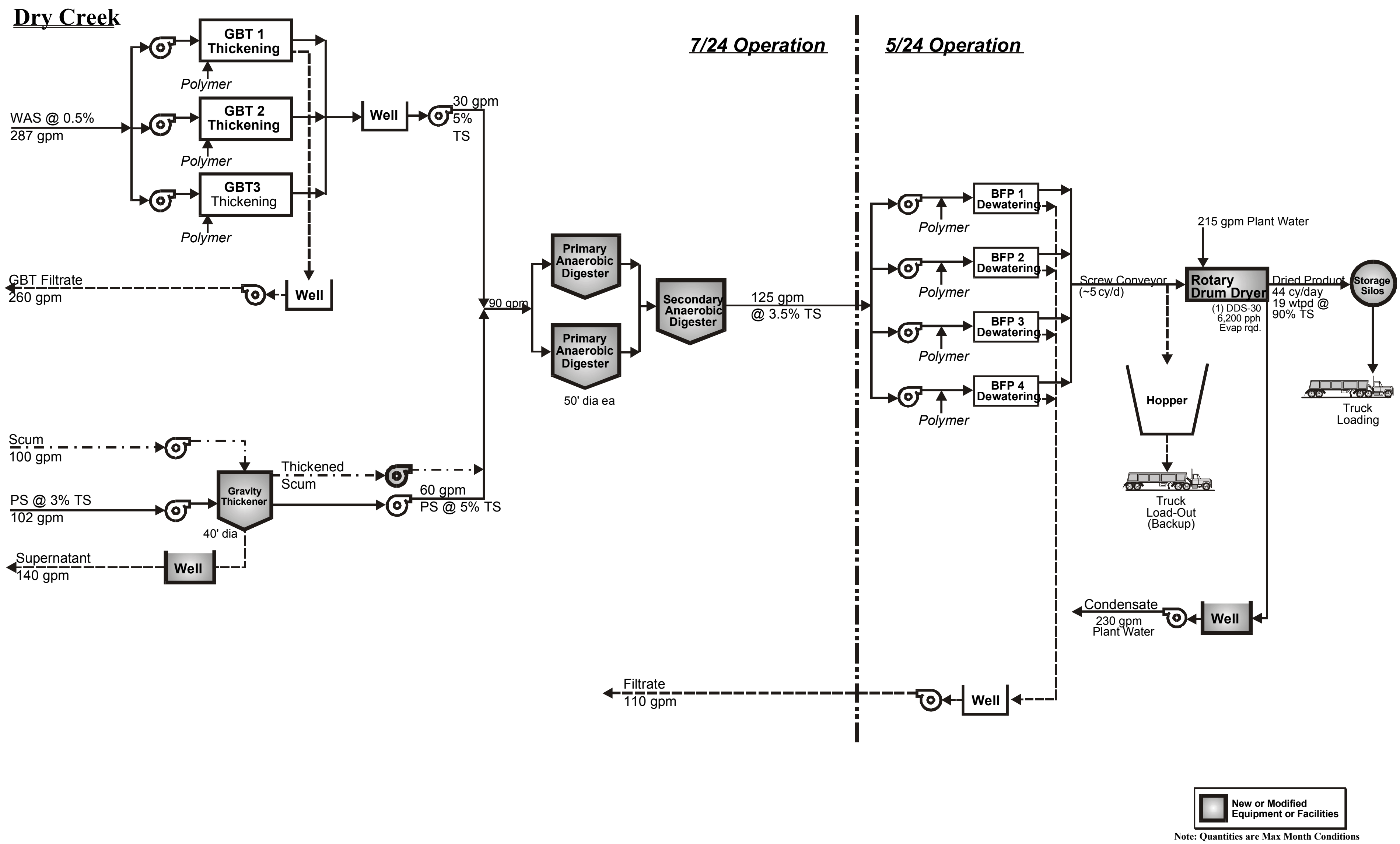

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NASHVILLE
ALTERNATIVE 19 (MODIFIED)-DRY CREEK FACILITY
HEAT DRY DIGESTED BIOSOLIDS

Figure IV-4b

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storage facilities will be installed adjacent to the existing dewatering and truck load-out structures. New conveyance systems will be installed to transfer dewatered cake from the BFPs to the new drying facility. Gas produced during anaerobic digestion will be used to offset a portion of the natural gas requirements of the drying process. The drying equipment will be operated five days per week. Distribution and marketing functions will be performed by contract. This alternative will require the following new facilities or modifications to existing facilities:

- One 40-foot diameter gravity thickeners with surface skimming and cover.
- Conversion of existing storage tanks to provide two primary digesters.
- Construction of 50-foot diameter secondary digester.
- Ferric feed and storage for struvite control.
- Drying building.
- One rotary drum dryer system.
- Allowance to replace two existing belt filter presses during project life.

B. Economic Evaluation

An economic evaluation was performed to compare capital and operating costs of the selected treatment alternatives. Each of these evaluations was based on the present value over a 20 year project life, using an interest rate of 5 percent. The capital and operating costs address only the processes associated with solids treatment and handling. Costs include site work and piping allowances to integrate new or relocated treatment processes with the existing liquid stream operations. Equipment requirements and costs were generated using the estimated future plant solids quantities listed in Table III-1. Operating costs were increased throughout the project life to reflect both a 1 percent annual increase in solids and unit cost increases due to inflation.

The selection and sizing of treatment processes at Central and Whites Creek were made with the connecting pipeline in mind. Consequently, the solids handling processes at these treatment plants were considered interdependent and a single, total cost was developed for the combined system. In contrast, the Dry Creek processes were not affected by operations at the other plants and its cost was independent of the combined Central and Whites Creek cost.

1. Expected Project Costs and Unit Costs

Construction and design factors were applied to capital costs to generate total expected project costs. Capital costs include facility, equipment, sitework, electrical, instrumentation and controls (EI&C) costs. Construction and design factors include contractor general requirements (10 percent), contingencies (25 percent) and engineering and administration (15 percent).

Unit costs were based on current costs to Metro Water Services. Unit costs for materials not currently used at any of the treatment plants were based on typical national values. The unit costs used in this evaluation were as follows:

Power	
Central	$0.025/kwh
Whites Creek and Dry Creek	$0.033/kwh
Labor	
Operators	$21/hr
Shift Operator	$28/hr
Supervisor	$33/hr
Maintenance	$27/hr
Chemicals	
Potassium Permanganate	$1.31/lb
Polymer (based on 6% active as delivered)	$1.317/lb active polymer
Ferric Chloride	$0.45/lb Fe
Sodium Hydroxide	$0.45/gallon
Sodium Hypochlorite	$0.50/gallon
Cake Hauling and Tipping Fee	$26.10/wt
Natural Gas	$6/MMBtu

Unit costs for power, labor, cake hauling and tipping, and all chemicals excluding ferric chloride were based on actual unit costs incurred by Metro Water Services. Labor costs were based on the staffing requirements for each treatment alternative listed in Appendix C. Ferric chloride and natural gas unit costs were based on typical national costs. Sale of heat dried product often results in a revenue stream that more than offsets transportation and handling costs associated with D&M; however, for this evaluation, revenue was considered to equal D&M, so neither revenue nor D&M costs were applied.

2. Present Value Costs

The present value costs used for this evaluation were developed using the expected project costs and operating costs for each alternative, based on the factors listed in the previous section. Present values costs, listed in Table IV-2, are presented in terms of 2001 dollars. Twenty-year O&M costs included annual increases in solids quantities and an annual inflation factor of 2.7 percent. The operating costs calculated in 2001 dollars, are listed in Table IV-2. Representative annualized unit costs across the project life are also shown as a cost per dry ton of biosolids. Detailed costs for Central/Whites Creek and Dry Creek are presented in Appendix B. A summary of the costs is presented in Table IV-2 and in Figure IV-6. With the exception of Alternative 10 – Landfilling Raw Cake - the present value costs of the evaluated alternatives differ by 15 percent or less. Typically, at budget level analysis, cost differences of 10 to 15 percent are not considered significant.

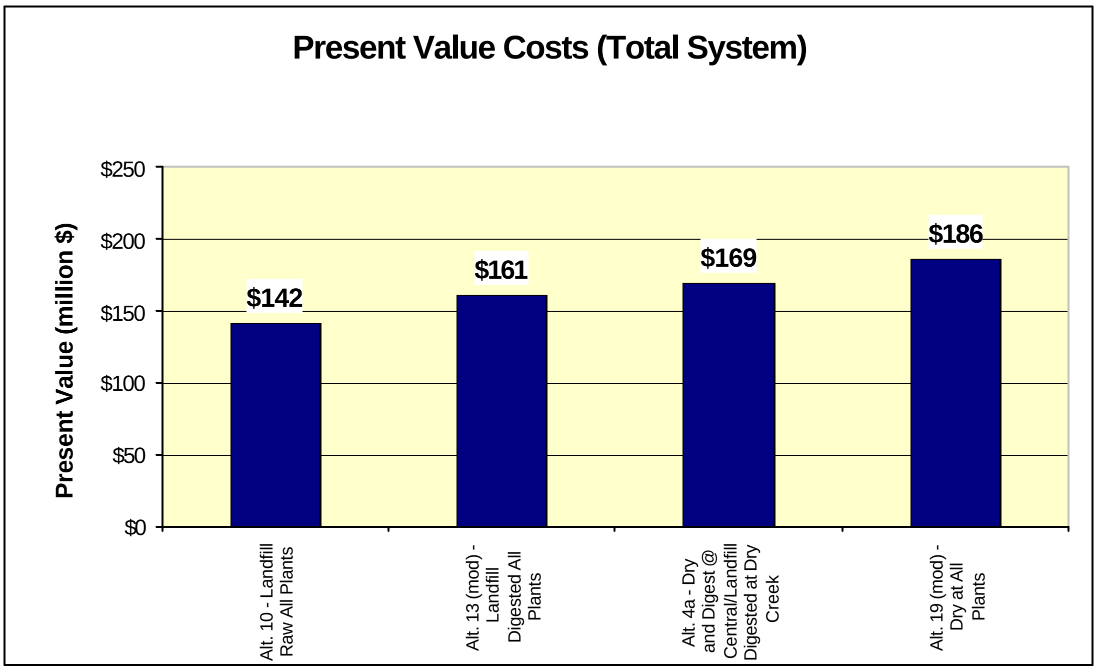

Figure IV-6.

Table IV-2. Summary of Alternative Costs			
	Project Cost **($ millions)**	**Annual O&M (2001)** **($ millions/yr)**	**Present Value** **($ millions)**
Alternative 10– Landfill Raw, Dewatered Solids from Central and Dry Creek, Pump Raw Thickened Solids from Whites Creek to Central			
Central/Whites Creek	$42.9	$ 4.9	$122.0
Dry Creek	$ 3.6	$ 1.0	$ 19.6
Total	***$46.5***	***$5.9***	***$141.6***
Alternative 13 (modified) – Landfill Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central			
Central/Whites Creek	$65.6	$4.2	$133.8
Dry Creek	$11.0	$1.0	$ 27.4
Total	***$76.6***	***$5.2***	***$161.2***
Alternative 4a – Heat Dry Digested, Dewatered Solids from Central, Pump Raw Solids from Whites Creek to Central, Landfill Digested, Dewatered Solids from Dry Creek			
Central/Whites Creek	$ 95.4	$3.0	$141.9
Dry Creek	$ 11.0	$1.0	$ 27.4
Total	***$106.4***	***$4.0***	***$169.3***
Alternative 19 (modified) – Heat Dry Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central			
Central/Whites Creek	$ 93.8	$3.3	$144.4
Dry Creek	$ 23.9	$1.2	$ 41.7
Total	***$117.7***	***$4.5***	***$186.1***

3. Sensitivity Analysis

The present worth costs listed in the previous section assume that unit costs, such as tipping fees, power, and labor rates, remain constant relative to one another through the life of the project. However, actual costs are likely to increase at varying rates depending on many different factors, including inflation, health of the economy in the area around Nashville, and changing contract agreements. A sensitivity analysis was performed to compare the effects of varying operating costs on the present value costs of the alternatives. The sensitivity analysis was performed using the landfill transport/tip fee in place at the time of the study of $29.30.

The sensitivity analysis focused on three cost parameters: landfill transport and tip fees, natural gas prices, and potential product revenue. Each of these factors was varied while other costs were held constant to determine its affect on the present value costs of the alternatives.

Landfill Transport and Tip Fees. Varying these fees has a significant effect on the present worth costs of the alternatives. Increasing the fee of approximately $29.30/wet ton to $32/wet ton (an increase of 13 percent) makes the cost of Alternative 4a – heat drying at Central, landfilling of digested solids at Dry Creek – equal to the cost of Alternative 13 (modified) – landfilling of digested solids from Central and Dry Creek. However, transport and tip fees must increase to $40/wet ton (an increase of 35 percent) to make the cost of Alternative 4a equal to that of Alternative 10 – landfilling of raw solids from Central and Dry Creek.

Natural Gas Prices. Current natural gas rates vary from around $4 to $7 per MMBTU depending on location and volume used. A rate of $6/MMBTU was used to develop the present worth costs shown in the previous section. The rate would have to drop by 33 percent, to $4/MMBTU, before the present worth cost of Alternative 4a equaled that of Alternative 13 (modified), at the current landfill transport and tipping fees.

Product Revenue. The evaluation used for determining present worth costs did not assess transport cost for heat dried product. Instead, it was assumed that the revenue generated through the sale of the pelletized product would offset transport and any other handling costs. However, it is possible that some net revenue would be realized for the product. The sensitivity analysis showed that a net revenue stream of $6/ ton of product was required for Alternative 4a costs to equal Alternative 13 (modified) costs. A product revenue of $51/ ton of product would be required before Alternative 4a costs equaled those of Alternative 10.

C. Non-Economic Evaluation

Non-economic criteria were established by the workshop participants during Workshop #2. These criteria were used to evaluate the *process technologies* used in the treatment alternatives, rather than the combination of treatment options in each of the listed alternatives. The criteria and evaluation are presented in Table IV-3 and are discussed in the following section.

Table IV-3. Non-Economic Evaluation Results			
Parameter	Landfill Raw, Dewatered Cake	Landfill Digested, Dewatered Cake	Heat Dry Digested Cake
Reliability	Good	Good	Good
Flexibility of Disposal Outlets	No Backup	No Backup	Landfill as Backup
Exposure to Outside Constraints	Landfill Availability Trucking Problems	Landfill Availability Trucking Problems	Natural Gas Supply
Ease of Implementation	Good	Good	Good
Ease of Operation	Most Simple	Good	Most Complex
Public Acceptance			
Product Odors	High Risk	Reduced Risk	Reduced Risk
Siting	Good	Good	Good
Health Concerns	Limited	Limited	Unlikely
Traffic	High	High	Low

1. Landfill Raw, Dewatered Cake

Landfilling of raw, dewatered cake is the treatment and disposal process currently being used at both the Central and Dry Creek plants. This process has been shown to be reliable and fairly simple to operate. In addition, implementation would be very straightforward, since it would require very few changes to the current treatment and disposal methods. No permitting changes would be required. However, this treatment technology also has some significant drawbacks. A major concern of handling raw solids is off-site odors, which have already been an issue at Central and Dry Creek. In addition, cake spills during hauling can cause odor and health concerns with the public. Another drawback includes its lack of flexibility. While landfill space is expected to be available throughout the life of this project, there are no other disposal options for raw sludge. Some states have adopted regulations that prevent landfilling raw sludge. Also, since many landfills are privately owned, they can set their own rules about whether to accept raw sludge. Consequently, if landfill availability changes, Metro Water Services will be forced to modify the solids treatment processes or haul raw, dewatered cake to a landfill outside of the area. There are also drawbacks associated with this alternative's dependence on trucking, including significant truck traffic through the neighborhoods adjacent to Central and Dry

Creek. Since no solids storage is provided for this alternative, trucking constraints due to inclement weather or contract issues can disrupt the solids treatment process.

2. Landfill Digested, Dewatered Cake

Landfilling of digested, dewatered cake adds some treatment processes and complexity to the current system. This process has been shown to be reliable and relatively simple to operate. Implementation would also be straightforward, since it requires only moderate changes to the current treatment and disposal methods. No permitting changes would be required. In addition, the stabilization provided through digestion significantly decreases the potential for off-site odors and health concerns associated with cake spills during hauling. This treatment technology still has drawbacks associated with hauling and disposal, including its lack of flexibility. If landfill availability changes, Metro Water Services will be forced to modify the solids treatment processes or haul cake to a landfill outside of the area. Digestion has little effect on truck traffic, so the disadvantages associated with trucking constraints due to inclement weather or contract issues are still concerns.

3. Heat Dry Digested, Dewatered Cake

Heat drying of digested, dewatered cake is the most complex alternative evaluated. However, this process has been shown to be reliable at other communities. Implementation would be fairly straightforward, under the condition that distribution and marketing (D&M) be performed by contract. In addition, this alternative offers a significant advantage through its flexibility. If production or disposal of dried pellets is interrupted, the digested, dewatered cake can be landfilled. Since the dried pellets are approximately one-fifth the volume of dewatered cake, the amount of truck traffic is drastically reduced. In addition, the Class A pathogen stabilization provided by heat drying minimizes health concerns associated with biosolids.

V. DELIVERY OPTIONS

The treatment alternatives discussed in the previous section can be implemented using a traditional design, bid, construction delivery system or some alternative delivery method. Using the traditional approach, each step in the delivery is a separate task, with its own timeline. In the alternative delivery options, several steps can be performed simultaneously, decreasing the total time required for project implementation. These alternatives are discussed briefly in the following section.

A. Traditional Delivery

The traditional design-bid-build approach has been the typical method of implementing projects by public entities. In this approach the Owner selects the engineer to design the project and serve as the Owner's agent during construction, providing construction administration and inspection services. The steps for project implementation using this approach include selection of the design engineer, detailed design, bidding and award of construction contract, construction, and commissioning. The total estimated time using this approach to implement the project would be 52-67 months.

The advantage of this delivery method is that it is most familiar to Metro Water and the Purchasing Department and it provides Metro Water with the most control in decision making during design and construction. This process provides for a completed design prepared by a professional engineer acting as a consultant to the Owner. The Engineer and Owner work together to define the project objectives and details of the design.

The disadvantage is that the linear and sequential process of the traditional delivery method has a longer project schedule and typically results in higher project cost than alternative methods.

B. Design/Build Delivery

This delivery method requires selection of a design/build team that usually consists of an engineering company and a general contractor. In this approach, the Owner selects an engineer to assist in preparation of the design/build request for proposals. The design/build RFP package includes a preliminary design (20%-30%) that establishes the intent, character, design criteria, level of quality and project scope. The steps for implementation using this approach include selection of Owner's engineer, preparation of preliminary design, selection of design/build team, design, construction, and commissioning. The total estimated time using this approach to implement this project would be 54-65 months.

The advantages of this delivery method are that it provides the Owner with one entity responsible for design and construction. Also, design/build can have a shorter overall project schedule, if the design/build selection process is expedited, and stimulate innovative solutions.

The disadvantages of this approach are that it provides less Owner overall control and limits the input the Owner has on the final design. Also, the selection process for the design/build team typically takes 12-15 months.

C. Design/Build/Operate Delivery

This delivery method is the same as design/build except that it requires the Contractor to operate the facilities for a stipulated period of time. The DBO team typically consists of a design engineer, a general contractor, and an operations firm. The DBO contract is typically between the Owner and the operations firm. The operations firm typically subcontracts design and construction. In this approach, the Owner selects an advisory team to assist in preparation of the DBO request for proposals. The advisory team typically consists of a lead DBO advisor, a legal advisor, a technical advisor and a financial advisor. The steps for implementation using this approach includes selection of advisory team consultants, pre-qualification of DBO firms, selection of DBO team, negotiation of DBO contract, design, construction, and commissioning. The total estimated time using this approach to implement this project would be 60-69 months.

The advantages of this delivery method are it provides the Owner with one entity responsible for design, construction, and operation and it reduces the Owner's operating responsibility and staff.

The disadvantages of this approach are that it typically takes 18-24 months to select a DBO contractor, which results in a longer overall project schedule compared to other delivery methods. It reduces the Owner's input in the final design and it limits competition. There are only a limited number of operating companies capable of leading a DBO project of this scale. .

D. Design/Construction Management Delivery

This delivery method requires selection of an engineer to design the project and a contractor to manage the construction. The engineer and construction manager work together to break the job up into multiple construction/procurement packages. The construction packages are bid, awarded, and construction or equipment manufacturing proceeds while the design continues. The steps for implementation using this approach include selection of the design engineer, selection of the construction manager, design, construction and commissioning. The total estimated time using this approach to implement this project would be 48-53 months.

The advantages of this delivery method are that it can provide a shorter overall project schedule than other delivery methods. The Owner maintains a significant decision-making role in the design and equipment selection, and there is increased competition by breaking the project into multiple packages.

The disadvantages of this approach is that delays can result if Purchasing Department processes are not expedited and the total project cost is not known at the start of construction. Final project cost is determined by the sum of all the bid packages.

VI. RECOMMENDATIONS

All of the options evaluated in Section IV provide viable, long-term solutions for Metro Water Services. During the evaluation, the project team expressed interest in improving the thickening and dewatering facilities at Central, addressing on- and off-site odors at Central and Dry Creek, increasing primary and WAS solids storage at Dry Creek, and addressing grease and scum handling at Central and Dry Creek. All of the treatment alternatives address these concerns through equipment or process modifications.

A. Selected Process

Based on the economic and non-economic evaluations, the project team has selected Alternative 4(a) – heat drying digested solids at Central, landfilling digested solids at Dry Creek – as the preferred long term program. This alternative has the second highest capital costs, but has the lowest O&M costs. Consequently, the net present value of this alternative is comparable to the other alternatives (with the exception of Alternative 10 – landfilling raw solids), yet the non-economic benefits of adding drying are significant.

Installation of digestion should both minimize off-site odors at Central and Dry Creek and improve the operating environment in the solids handling facilities. Digestion and heat drying at Central will produce a Class A biosolids, reduce both solids mass and volume, and is expected to decrease the truck traffic at Central by almost 70 percent, making this alternative neighborhood friendly. Digestion at Dry Creek will produce a Class B biosolids and also reduce solids mass, with a corresponding 20 percent decrease in truck traffic. Metro Water could team with the private sector to provide additional treatment to meet Class A requirements and produce biosolids that could have beneficial reuse.

Selection of this alternative also allows recycling of the majority of Metro Water Services' solids. All solids from Central and Whites Creek will be suitable for distribution as an organic fertilizer at the regional or national level. However, facilities will be provided to allow flexible management options at Central, increasing available outlets for the treated solids.

B. Implementation

The recommended delivery method for implementation of the improvements to the biosolids facilities at the Central WWTP is design/build. A two-step procurement approach using performance-based standards and "best value" selection criteria is recommended.

This delivery method allows responsibility for design and construction of the project to be assigned to a single entity. By combining design and construction responsibilities, the project schedule can be accelerated.

The recommended delivery method for implementation of the improvements to the biosolids facilities at the Dry Creek WWTP is design-bid-build. Coordination of the design with the existing facilities is crucial for this project and, therefore, lends itself to a more traditional approach with maximum Owner input in the design.

During the construction of the Biosolids facilities at the Central Plant WWTP, there will be a solicitation for a contractor to provide the marketing and distribution of the dried, finished product. This will be handled through a RFP and evaluated bid process.

APPENDIX A

WORKSHOP MINUTES

WORKSHOP # 1

BIOSOLIDS MANAGEMENT PLAN - SCREENING WORKSHOP

The Screening Workshop was held on 28 August 2001 at the Harrington Water Treatment plant. The following people participated in the workshop:

Metro Water Services	Black & Veatch	Katcher Vaughn & Bailey
Chace Anderson (Metro Public Works)	Gary Shimp	Roy Vaughn
Ron Ballard	Roger Lindsey	Dana Coleman
Butch Bryant	Scott Carr	Heather Buckner
Ken Cox	Shannon Lambert	
Linda Green	Patricia Scanlan	
Ron Taylor		
David Tucker		
Diane Thorne (Metro Gov't)		
Joe White		

The workshop agenda was as follows:

- Introduction to in-plant solids handling and treatment.
- First impressions of current biosolids management, review of existing facilities and practices.
- Overview of planning methodology.
- Discussion of management practices and associated technology options.
- Screening to identify management practices and technologies most worthy of consideration for Metro Water Services.

A. Introduction to In-Plant Solids Handling and Treatment

This discussion included an overview of typical primary and secondary sludge characteristics, thickening, dewatering, and stabilization technologies, and the typical benefits, drawbacks, and suitable applications for each of the technologies.

B. First Impressions

An overview of the current solids treatment processes used at each of the three facilities - Central, Whites Creek, and Dry Creek - were presented and discussed. Areas of concern existing at each of the plants was also discussed. These included:

- Poor condition of thickening and dewatering facilities at Central. The facilities are not conducive to good operation.
- Off-site odors at Central.
- Uncertain condition of the pipeline from Whites Creek to Central.
- Pipeline conveyance dictates operating practices to maintain dilute sludge at Whites Creek (~ 2 percent solids).
- Potential use of existing digester tankage at Whites Creek.
- Possibility of using onsite co-generation facilities at Whites Creek with digester gas.
- Generally good condition of the thickening, storage, and dewatering at Dry Creek.
- On-going odor control study at Dry Creek.

C. Planning Methodology

The methodology for the alternative evaluations was discussed. This consisted of a "total picture" approach including:

- Final Use/Disposal.
- Location.
- Stabilization Technology.
- Conveyance.
- Support Processes.

In an effort to "fast track" the evaluation, the process approach included sorting the myriad of available technologies into "Metro Own/Operate" vs. "Private Sector Provided" alternatives.

D. Discussion of Final Use/Disposal Options

Prior to discussing technology options, issues that affect final use/disposal practices were addressed, including a more informed and vocal public, limitations of the existing facilities at Metro, advancements in technology since the last facility expansion, and tighter regulatory requirements.

Technology options were divided into final use or disposal categories for discussion. These categories were:

- Land Application – including bulk land application (Class B).
- Distribution and Marketing – including "Advanced" processing to generate Class A biosolids.
- Landfill.
- Incineration.
- Conversion to/use in commercial products – including *Minergy* glass aggregate production.
- Conversion to/use as a fuel product – including *Primenergy* sludge to oil processes.

Alternative delivery systems were discussed. This exchange focused on benefits and drawbacks of the conventional design/bid/build approach vs. design/build or design/build/operate through the private sector. Private sector players along with information about experiences at their facilities.

E. Screening to Identify Management Practices and Associated Technologies

The available management practices (final use and disposal practices) and associated technologies were discussed, addressing specific benefits and drawbacks in light of Metro Water Service's previous biosolids experiences. The initial alternative screening results from this workshop were as follows:

- Class B land application – ***ELIMINATED.***
- Distribution and Marketing of Class A Products:
  - Composting – ***FURTHER INFORMATION NECESSARY.***
  - Alkaline Stabilization of Class A product – ***FURTHER INFORMATION NECESSARY.***
  - Drying of raw solids – ***ADDED.***
  - Drying of digested solids – ***RETAINED.***
- Disposal Practices:
  - Landfill – ***RETAINED.***
  - Incineration – ***RETAINED.***

Based on the discussion, the group decided Class B land application would not be to considered further due to problems that Metro Water Services previously experienced with land application. In addition, nationwide trends appear to be moving away from Class B land application due to public issues.

Landfill was retained as a viable alternative for a primary disposal option.

The group had questions concerning the cost and viability of composting for a utility of Nashville's size. The discussion addressed probable odors associated with composting, problems of handling and distributing large quantities of compost, high traffic volume, and historical problems associated with Show-Me Farms, who had provided composting operations for Metro Water Services.

The group also discussed concerns with alkaline stabilization. Odors associated with lime stabilization were an issue. Incineration was discussed and while it was believed to be a viable alternative technically, it was thought to be a difficult fit with the current political climate.

The group also wanted to investigate the possibility of reversing pipeline transmissions from Central to Whites Creek and providing solids treatment at Whites Creek for the combined Central/Whites Creek solids. The idea behind this alternative was to minimize odor and truck traffic at the downtown facility.

Following the workshop, Black & Veatch staff were responsible for developing a list of viable options based on the management practices and technologies selected for further evaluation. More detailed information on the processes, such as equipment needs and truck volumes, were to be developed for consideration during Workshop #2.

WORKSHOP #2
BIOSOLIDS SYSTEM ALTERNATIVES SCREENING

The Biosolids System Alternatives Screening Workshop was held on 23 October 2001 at the Harrington Water Treatment Plant. The following people participated in the workshop:

Metro Water Services	Black & Veatch	Katcher Vaughn & Bailey
Chace Anderson (Public Works)	Gary Shimp	Roy Vaughn
Ron Ballard	Roger Lindsey	Dana Coleman
Butch Bryant	Scott Carr	Heather Buckner
Ken Cox	Lew Naylor	
Linda Green	Shannon Lambert	
Ron Taylor	Patricia Scanlan	
David Tucker		
Diane Thorne (Metro Gov't)		
Joe White		

The workshop agenda was as follows:

- Observations from follow-up visits to treatment plants.
- Update from on-going odor control project.
- Discussion of composting and alkaline stabilization.
- Alternatives screening.
- Development of non-economic evaluation criteria.

A. Observations from Follow-up Visits to Treatment Plants

Additional visits to the three treatment plants were performed following the initial screening workshop. The intent of these visits was to clarify the solids treatment processes and scum handling, to investigate the practical use and/or retrofit of any existing facilities and site availability, and to clarify solids production quantities at the three plants. The solids production at the three plants for current and future conditions was discussed. Future conditions were based on 2020 population projections.

The condition of existing facilities and equipment was discussed. The information collected during the follow-up visits showed that the solids processing facilities at Central would not be easily retrofit. Modifying the solids handling building for either centrifuges or new belt filter presses would not likely be cost effective. The existing thickening building does not have significant useful life remaining and thickening and conveying equipment is corroded and needs replacement. Whites Creek thickening equipment appears adequate to support future thickening requirements. The dewatering facilities would require significant investment to return to use. The existing digester tankage could be retrofit, saving the expense of tankage construction, but modifications to the tank equipment (covers, mixing, pumps, etc) would be required. The condition of the Dry Creek facilities appear adequate to support future solids handling requirements.

Site requirements were discussed for new facilities at the three plants. Considerable area is available east of the Central plant, between the existing plant and the Cumberland River. This area is currently owned by the Metro Water Services and could be used for new facilities.

Investigation of the Whites Creek site for possible locations for either lime stabilization or composting facilities showed that lime stabilization could be supported on the current site; however, it would require area that has been earmarked for future liquid stream treatment expansion. Composting would be difficult to fit on the existing plant site. Privately-owned land to the northeast of the plant would potentially be suitable for a compost facility.

Evaluation of the Dry Creek facility showed that little land is available for new construction. Lime stabilization could be supported at the site; however, providing the recommended storage area would require land designated for equalization basin expansion. A five-acre area is available to the northeast of the plant; however, this was previously used as a sludge monofill. Construction on this site would require excavation and replacement with new fill dirt.

B. Composting and Alkaline Stabilization

An overview of the composting technologies, benefits and drawbacks, and requirements for a successful composting operation was presented and discussed. Alkaline stabilization processes for Class A material were also presented and discussed, including the N-Viro process with in-line thermal drying. Typical mass balances for both technologies were discussed.

C. Alternatives Screening

A matrix of treatment alternatives had been developed based on the results of Workshop #1. The management practices that were carried forward from the first workshop were as follows:

- Distribution and marketing of Class A solids:
  - Heat drying (raw or digested biosolids).
  - Alkaline stabilization (raw or digested biosolids).
  - Composting (raw or digested biosolids).
- Disposal:
  - Landfill disposal (raw or digested biosolids).
  - Incineration of raw biosolids.

Using these options, more than 200 treatment configurations were identified for the three-plant system. Based on a preliminary evaluation by Black & Veatch staff, the number of options was reduced to 26. A list of these options is shown in Table A-1. Based on discussion of the treatment technologies, the workshop participants determined that composting, alkaline stabilization, and incineration were not a good fit for Metro Water Services, based on a combination of site constraints, public policy, and potential odor issues. The group also discussed and eliminated pumping solids from Central to Whites Creek as a treatment option due to the effects of thickening and dewatering sidestreams on the liquid stream treatment and possible impacts on nearby residents. From the list of 26 alternatives, four alternatives were carried forward for budget level cost analysis. These are listed in Table A-2.

Table A-1. Treatment Alternatives			
	Central WWTP	**Whites Creek WWTP**	**Dry Creek WWTP**
1	Landfill raw, dewatered biosolids	Landfill raw, dewatered biosolids	Landfill raw, dewatered biosolids
2	Landfill digested, dewatered biosolids	Landfill digested, dewatered biosolids	Landfill raw, dewatered biosolids
3	Heat dry digested, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
4	Heat dry digested, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
5	Heat dry digested, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Alkaline stabilize raw, dewatered biosolids
6	Heat dry digested, dewatered biosolids	Compost digested, dewatered biosolids	Landfill raw, dewatered biosolids
7	Incinerate raw, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
8	Pump raw, thickened biosolids to White's Creek WWTP	Alkaline stabilize raw, dewatered biosolids	Alkaline stabilize raw, dewatered biosolids
9	Pump raw, thickened biosolids to White's Creek WWTP	Heat dry digested, dewatered biosolids	Landfill raw, dewatered biosolids
10	Landfill raw, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
11	Landfill digested, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Alkaline stabilize raw, dewatered biosolids
12	Landfill digested, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
13	Landfill digested, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
14	Heat dry raw, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids

Table A-1 (con't). Treatment Alternatives			
	Central WWTP	**Whites Creek WWTP**	**Dry Creek WWTP**
15	Heat dry raw, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Heat dry raw, dewatered biosolids
16	Heat dry raw, dewatered biosolids	Compost digested, dewatered biosolids	Landfill raw, dewatered biosolids
17	Heat dry raw, dewatered biosolids	Compost digested, dewatered biosolids	Truck digested, dewatered biosolids to White's Creek WWTP for composting
18	Heat dry raw, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Landfill raw, dewatered biosolids
19	Heat dry digested, dewatered biosolids	Pump digested, thickened biosolids to Central WWTP	Heat dry raw, dewatered biosolids
20	Alkaline stabilize raw, dewatered biosolids	Alkaline stabilize raw, dewatered biosolids	Alkaline stabilize raw, dewatered biosolids
21	Alkaline stabilize raw, dewatered biosolids	Pump raw, thickened biosolids to Central WWTP	Alkaline stabilize raw, dewatered biosolids
22	Pump raw, thickened biosolids to White's Creek WWTP	Heat dry raw, dewatered biosolids	Landfill raw, dewatered biosolids
23	Pump raw, thickened biosolids to White's Creek WWTP	Heat dry raw, dewatered biosolids	Heat dry raw, dewatered biosolids
24	Pump raw, thickened biosolids to White's Creek WWTP	Heat dry digested, dewatered biosolids	Heat dry raw, dewatered biosolids
25	Pump raw, thickened biosolids to White's Creek WWTP	Incinerate raw, dewatered biosolids	Landfill raw, dewatered biosolids
26	Pump raw, thickened biosolids to White's Creek WWTP	Incinerate raw, dewatered biosolids	Alkaline stabilize raw, dewatered biosolids

Table A-2. Treatment Alternatives Selected for Additional Evaluation			
Alt No.	Central	Whites Creek	Dry Creek
10	Landfill raw, dewatered biosolids	Pump raw, thickened biosolids to Central	Landfill raw, dewatered biosolids
13 (mod)	Landfill digested, dewatered biosolids	Pump digested, thickened biosolids to Central	Landfill digested, dewatered biosolids
4	Heat dry digested, dewatered biosolids	Pump digested, thickened biosolids to Central	Landfill raw, dewatered biosolids
19 (mod)	Heat dry digested, dewatered biosolids	Pump digested, thickened biosolids to Central	Heat dry digested, dewatered biosolids

Alternatives 13 and 19 were modified by the team from the original list of 26 by adding anaerobic digestion for solids stabilization at Dry Creek. Following the Workshop #2, team members met with Metro Government officials and briefed them on project status and alternative selection results. As a result of the briefing, a fifth evaluation alternative was added – Alternative 4 (modified) – Heat dry digested, dewatered biosolids from Whites Creek and Central (at Central) and landfill digested, dewatered biosolids from Dry Creek.

A sixth alternative was developed during the economic evaluation based on Alternative 4 (modified). This option, Alternative 4a, also provided heat drying at Central and landfilling of digested solids at Dry Creek, but pumped raw solids from Whites Creek to Central for digestion.

D. Development of Non-economic Evaluation Criteria

The workshop participants developed a list of non-economic criteria to use for alternative evaluation. The criteria are presented below, in no order of precedence:

- Reliability of operations.
- Exposure to "Outside" conditions:
  - Fuel shortages.
  - Pipeline breaks.
  - Inclement weather.
- Ease of implementation/continuity of operation.
- Ease of operations.

- Public acceptance.
- Neighborhood impacts:
  - Odor potential.
  - Siting.
  - Trucking.
  - Perception.
- Flexibility of disposal outlets.

These criteria will be used in conjunction with the cost information to perform the final alternative evaluations.

WORKSHOP # 3
PROGRESS WORKSHOP

The Progress Workshop was held on 11 December 2001 at the Harrington Water Treatment Plant. The following people participated in the workshop:

Metro Water Services	Black & Veatch	TDEC
Chace Anderson (Public Works)	Gary Shimp	Pamala Myers
Ron Ballard	Roger Lindsey	Roger LeMasters
Butch Bryant	Scott Carr	
Ken Cox	Shannon Lambert	
Linda Green	Patricia Scanlan	
Ron Taylor	Dana Coleman (KVB)	
David Tucker		
Joe White		
Bob Wingo		

This workshop consisted of a discussion of budget level capital and operating costs for each of the five alternatives selected in Workshop #2. Schematics and costs for each of the alternatives are presented in Appendix B. Expected staffing requirements used in developing labor costs are presented in Appendix C.

Based on workshop discussion, a Present Value model will be developed that will allow sensitivity analysis of alternative costs based on unit operating costs.

APPENDIX B

ALTERNATIVE COSTING

TABLE B-1

Alternative 10 – Landfill Raw, Dewatered Solids from Central and Dry Creek, Pump Raw Thickened Solids from Whites Creek to Central

Central and Whites Creek Costs

Project Costs

Whites Creek	
Pipeline	$3,792,000
Improvements to Existing Pipeline (allowance)	$359,000
Storage Tank Retrofit	$3,555,000
Odor Control Equipment	$538,000
Central	
Solids Handling Building	$11,720,000
WAS Thickening	$2,364,000
Thickened WAS Storage	$4,308,000
Scum Handling	$2,281,000
Primary Solids Storage	$4,308,000
Blend Tank	$118,000
Dewatering Equipment	$10,774,000
Cranes and Hoists	$299,000
Conveyance	$1,666,000
Yard Piping Allowance	$996,000
Odor Control Equipment	$837,000
Total Project Cost	***$42,860,000***

Annual Operating Costs	***$/yr***
Power	$140,000
Labor	$539,000
Hauling and Tipping	$2,817,000
Polymer	$356,000
Potassium Permanganate	$411,000
Odor Control (chemical use and power)	$421,000
Equipment Maintenance	$171,000
Total, Operating Costs	***$4,855,000***
Net Present Value	***$122,002,000***
Annualized Unit Cost	***$327***

Table B-2

Alternative 10 – Landfill Raw, Dewatered Solids from Central and Dry Creek, Pump Raw Thickened Solids from Whites Creek to Central

Dry Creek Costs

Project Costs

Solids Handling Building	$598,000
Scum Handling	$433,000
Primary Solids Storage	$1,068,000
Blend Tank	$51,000
Dewatering Equipment	$1,255,000
Yard Piping Allowance	$199,000
Total Project Cost	***$3,604,000***
Annual Operating Costs	***$/yr***
Power	$48,000
Labor	$202,000
Hauling and Tipping	$557,000
Polymer	$68,000
Potassium Permanganate	$81,000
Odor Control	$2,000
Equipment Maintenance	$13,000
Total, Operating Costs	***$971,000***
Net Present Value	***$19,603,000***
Annualized Unit Cost	***$264***

Table B-3

Alternative 13 (modified) – Landfill Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

<u>Central and Whites Creek Costs</u>

Project Costs

Whites Creek	
Improvements to Existing Pipeline (allowance)	$359,000
Primary Solids Thickening	$1,241,000
Anaerobic Digestion	$7,797,000
Yard Piping Allowance	$398,000
Central	
Solids Handling Building	$10,953,000
WAS Thickening	$1,566,000
Scum Handling	$83,000
Primary Solids Thickening	$2,412,000
Blend Tank	$65,000
Anaerobic Digestion	$27,921,000
Dewatering Equipment	$8,965,000
Cranes and Hoists	$299,000
Conveyance	$1,596,000
Yard Piping Allowance	$996,000
Odor Control Equipment	$901,000
Total Project Cost	***$65,552,000***

Annual Operating Costs	***$/yr***
Power	$188,000
Labor	$731,000
Hauling and Tipping	$2,019,000
Polymer	$494,000
Ferric Chloride	$212,000
Odor Control (chemical use and power)	$363,000
Equipment Maintenance	$228,000
Total, Operating Costs	***$4,235,000***
Net Present Value	***$133,844,000***
Annualized Unit Cost	***$360***

Table B-4

Alternative 13 (modified) – Landfill Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

Dry Creek Costs

Project Costs

Solids Handling Building	$598,000
Primary Solids Thickening	$1,006,000
Anaerobic Digestion	$7,979,000
Dewatering Equipment	$1,255,000
Yard Piping Allowance	$199,000
Total Project Cost	***$11,037,000***

Annual Operating Costs	***$/yr***
Power	$39,000
Labor	$245,000
Hauling and Tipping	$554,000
Polymer	$95,000
Ferric Chloride	$42,000
Equipment Maintenance	$18,000
Total, Operating Costs	***$993,000***
Net Present Value	***$27,350,000***
Annualized Unit Cost	***$371***

TABLE B-5

Alternative 4a – Heat Dry Digested, Dewatered Solids from Central, Pump Raw Solids from Whites Creek to Central, Landfill Digested, Dewatered Solids from Dry Creek

Central and Whites Creek Costs

Project Costs

Whites Creek	
Improvements to Existing Pipeline (allowance)	$359,000
Central	
Thickening Building	$4,686,000
WAS Thickening	$3,167,000
Scum Handling	$83,000
Primary Solids Thickening	$2,412,000
Blend Tank	$65,000
Anaerobic Digestion	$35,395,000
Dewatering Building	$8,268,000
Dewatering Equipment	$8,965,000
Cranes and Hoists	$299,000
Conveyance	$1,666,000
Yard Piping Allowance	$996,000
Drying Building	$3,238,000
Drying Equipment	$24,921,000
Odor Control Equipment	$901,000
Total Project Cost	***$95,355,000***
Annual Operating Costs	***$/yr***
Power	$256,000
Labor	$857,000
Natural Gas	$350,000
Polymer	$535,000
Ferric Chloride	$212,000
Odor Control (chemical use and power)	$368,000
Equipment Maintenance	$452,000
Total, Operating Costs	***$3,030,000***
Net Present Value	***$141,917,000***
Annualized Unit Cost	***$383***

TABLE B-6

Alternative 4a – Heat Dry Digested, Dewatered Solids from Central, Pump Raw Solids from Whites Creek to Central, Landfill Digested, Dewatered Solids from Dry Creek

Dry Creek Costs

Project Costs

Solids Handling Building	$598,000
Primary Solids Thickening	$1,006,000
Anaerobic Digestion	$7,979,000
Dewatering Equipment	$1,255,000
Yard Piping Allowance	$199,000
Total Project Cost	***$11,037,000***

Annual Operating Costs	***$/yr***
Power	$39,000
Labor	$245,000
Hauling and Tipping	$554,000
Polymer	$95,000
Ferric Chloride	$42,000
Equipment Maintenance	$18,000
Total, Operating Costs	***$993,000***
Net Present Value	***$27,350,000***
Annualized Unit Cost	***$371***

TABLE B-7

Alternative 19 (modified) – Heat Dry Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

<u>Central and Whites Creek Costs</u>

Project Costs	
Whites Creek	
Improvements to Existing Pipeline (allowance)	$359,000
Primary Solids Thickening	$1,241,000
Anaerobic Digestion	$7,797,000
Yard Piping Allowance	$398,000
Central	
Thickening Building	$2,685,000
WAS Thickening	$1,566,000
Scum Handling	$83,000
Primary Solids Thickening	$2,412,000
Blend Tank	$65,000
Anaerobic Digestion	$27,921,000
Dewatering Building	$8,268,000
Dewatering Equipment	$8,965,000
Cranes and Hoists	$299,000
Conveyance	$1,666,000
Yard Piping Allowance	$996,000
Drying Building	$3,238,000
Drying Equipment	$24,921,000
Odor Control Equipment	$901,000
Total Project Cost	***$93,781,000***

Annual Operating Costs	***$/yr***
Power	$309,000
Labor	$918,000
Natural Gas	$494,000
Polymer	$494,000
Ferric Chloride	$212,000
Odor Control (chemical use and power)	$363,000
Equipment Maintenance	$476,000
Total, Operating Costs	***$3,266,000***
Net Present Value	***$144,410,000***
Annualized Unit Cost	***$390***

TABLE B-8

Alternative 19 (modified) – Dry Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central

Dry Creek Costs

Project Costs

Solids Handling Building	$598,000
Primary Solids Thickening	$1,006,000
Anaerobic Digestion	$7,979,000
Dewatering Equipment	$1,255,000
Yard Piping Allowance	$199,000
Drying Building	$1,743,000
Drying Equipment	$11,114,000
Total Project Cost	***$23,894,000***

Annual Operating Costs	***$/yr***
Power	$71,000
Labor	$501,000
Natural Gas	$193,000
Polymer	$95,000
Ferric Chloride	$48,000
Equipment Maintenance	$249,000
Total, Operating Costs	***$1,157,000***
Net Present Value	***$41,724,000***
Annualized Unit Cost	***$569***

APPENDIX C

EXPECTED STAFFING REQUIREMENTS

Staffing Requirements for Biosolids Treatment and Management												
	Operator[1]			Senior Operator			Supervisor			Maintenance		
	No.Shift	Shifts/day	Days/wk	No.Shift	Shifts/day	Days/wk	No.Shift	Shifts/day	Days/wk	No.Shift	Shifts/day	Days/wk
Alternative 10– Landfill Raw, Dewatered Solids from Central and Dry Creek, Pump Raw Thickened Solids from Whites Creek to Central												
Central	1	3	7	1	3	5	1	1	5	2	1	5
Whites Creek	-	-	-	-	-	-	-	-	-	-	-	-
Dry Creek	1	2	5	1	1	5	-	-	-	1	1	5
Alternative 13 (modified) - Landfill Digested, Dewatered Solids from Central and Dry Creek, Pump Digested Solids from Whites Creek to Central												
Central	2/1	3/3	5/2	1	3	5	1	1	5	2	1	5
Whites Creek	1	1	7	-	-	-	-	-	-	-	-	-
Dry Creek	1/1	2/1	5/5	1	1	5	-	-	-	1	1	5
Alternative 4a - Heat Dry Digested, Dewatered Solids from Central, Pump Raw Solids from Whites Creek to Central for Digestion, Landfill Digested, Dewatered Solids from Dry Creek												
Central	3/1	3/3	5/2	1	3	5	1	1	5	3	1	5
Whites Creek	-	-	-	-	-	-	-	-	-	-	-	-
Dry Creek	1/1	2/1	5/5	1	1	5	-	-	-	1	1	5
Alternative 19 (modified) – Dry Digested, Dewatered Solids from Central, Pump Digested Solids from Whites Creek to Central												
Central	3/1	3/3	5/2	1	3	5	1	1	5	2	1	5
Whites Creek	1	1	7	-	-	-	-	-	-	-	-	-
Dry Creek	2	3	5	1	1	5	1	1	5	2	1	5

[1]Multiple numbers indicate differing shift schedules. For instance, Alternative 13 at Central, calls for 2 operators, 3 shifts/day, 5 days/week plus 1 operator, 3 shifts/day, 2 days/week.